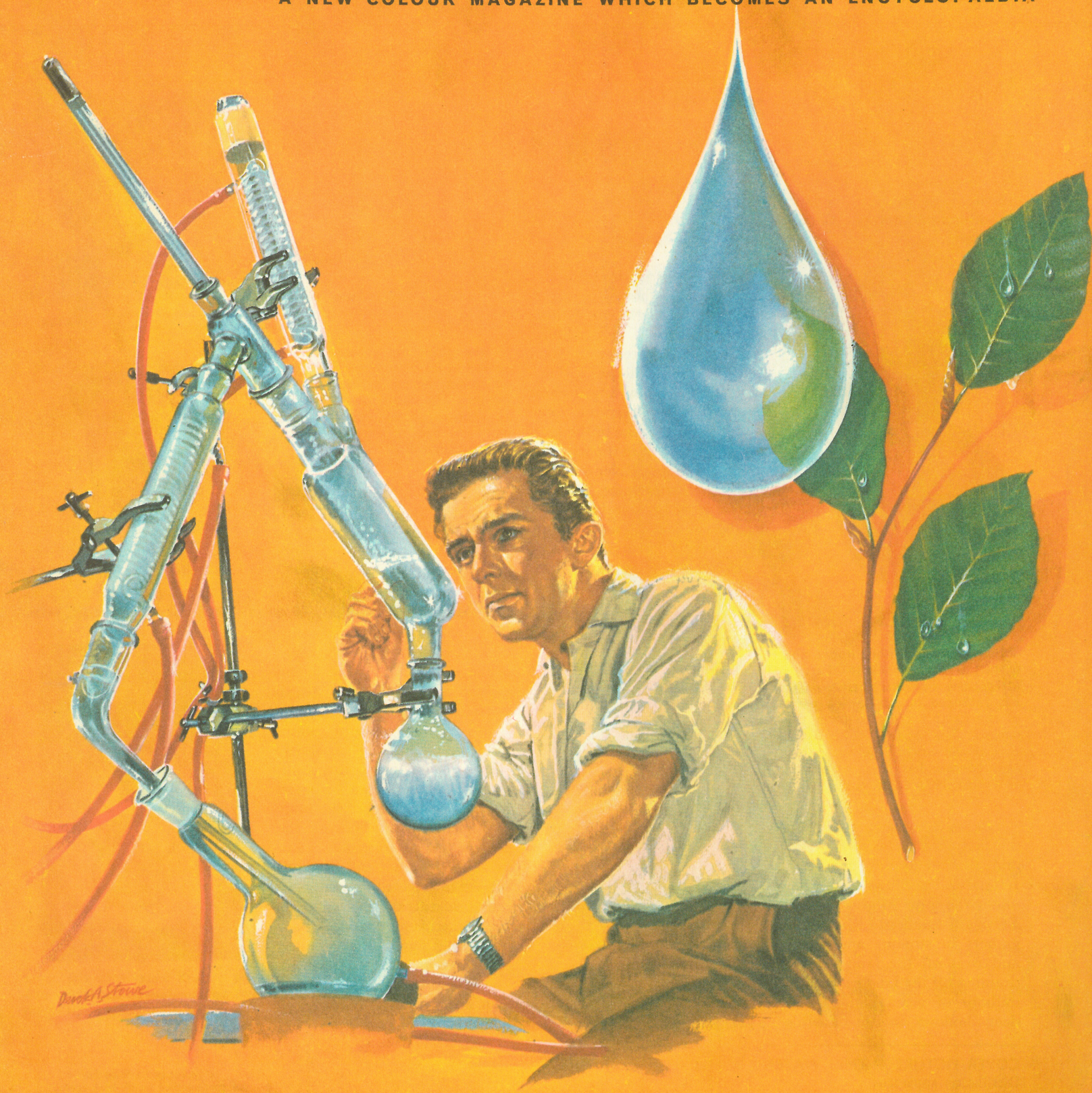
No. 1 EVERY MONDAY 2/-

Understanding SCIENCE

A NEW COLOUR MAGAZINE WHICH BECOMES AN ENCYCLOPAEDIA



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THE PLAN OF UNDERSTANDING SCIENCE

Each issue of *Understanding Science* will contain a selection of articles, each of which is a carefully planned member of a family of articles – a complete outline of a particular science. In this issue appear the first articles in nine of the different series as follows:

Water and Life on Earth—the first article in the General Science series; The Fireless Locomotive—the first article in the Heat Physics series; Floating and Sinking—the first article in the Hydrostatics series; Newton's Colour Disc—the first article in the Famous Scientists series; Everything is Made of Atoms—What are Atoms Made Of?—the first article in the Atomic Chemistry series; Using a Micrometer—the first article in the Technology series; All Living Things are Made of Cells—the first article in the Biology series; An Electric Circuit—the first article in the Electricity series; Time and Time Zones—the second article in the General Science series; The 'Loves' and 'Hates' of Magnets—the first article in the Magnetism series.

There are many series—nearly fifty in all, in fact. For some of them, articles will frequently appear and some only occasionally, according to the size of the subject.

SEE INSIDE BACK COVER FOR CONTENTS OF NEXT WEEK'S ISSUE.

GENERAL SCIENCE

Water and Life on Earth

WATER is probably the most important substance to everything that lives on Earth. It is in fact the basis of both animal and plant living processes.

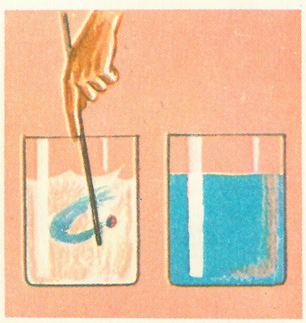
Water flows downhill under the force of gravity (the Earth's attraction). For this reason water has gathered in the lowest parts of the Earth's crust to form the oceans. The oceans cover over 70% of the world. The water they now contain has been estimated at almost 340 million cubic miles.

Life on Earth depends upon the fact that water is a liquid and, like all liquids, can flow. It naturally flows downhill under the force of gravity (the Earth's attraction). Rainwater gathers in streams and rivers and runs off the land. Water draining off the land masses for millions of years gathered in deep hollows in the Earth's crust to form the oceans. These hollows have the most complicated shapes but they are completely filled with water up to a certain level, for water can alter its shape to match its container.

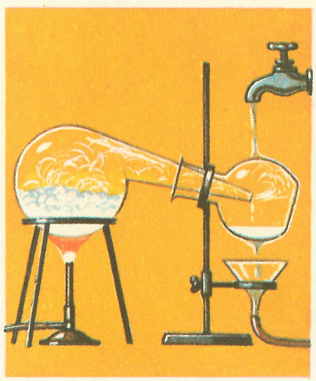
Water flowing downhill has the power to move objects. A small stream might carry along with it just mud and pebbles, but the same stream in flood could tear down houses and uproot trees. Day by day streams and rivers are carrying loose material off the face of the land and 'dumping' it in the sea. The great Mississippi River of North America carries some 500 million tons of broken-down rock to the sea in a single year. Water can be harnessed to work machinery too, anything from a water-mill to a hydro-electric turbine.

Water for Life

All animals and plants need water. One reason for this is that they are mostly made of water. It is easy to believe that



Given sufficient time, water has the power to dissolve most substances.

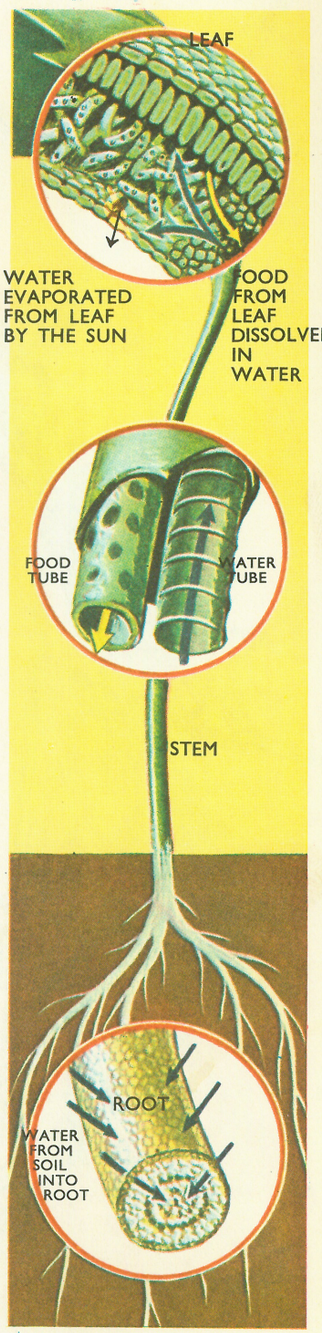


Water often has substances dissolved in it. If the water is turned to steam the substances are left behind. The steam can then be led to another vessel where it cools and turns back to water. This process is called *distillation*.

nine-tenths of a jellyfish is water, but about three-quarters of the human body is water too.

Land animals are able to take in water by drinking, a process which involves moving parts of their bodies by muscles. The heart, a muscular organ, is able to pump blood (which is mostly water) to all parts of the body through the blood vessels. Because water loses and gains heat so slowly (slower than any other substance) the blood can transport heat from one part of the body to another. Also because the body contains so much water its temperature will not be subject to rapid ups and downs. For this reason chemical reactions within the body are not slowed down or accelerated to any great extent.

A plant cannot move of its own accord, yet it manages to take water up from the soil

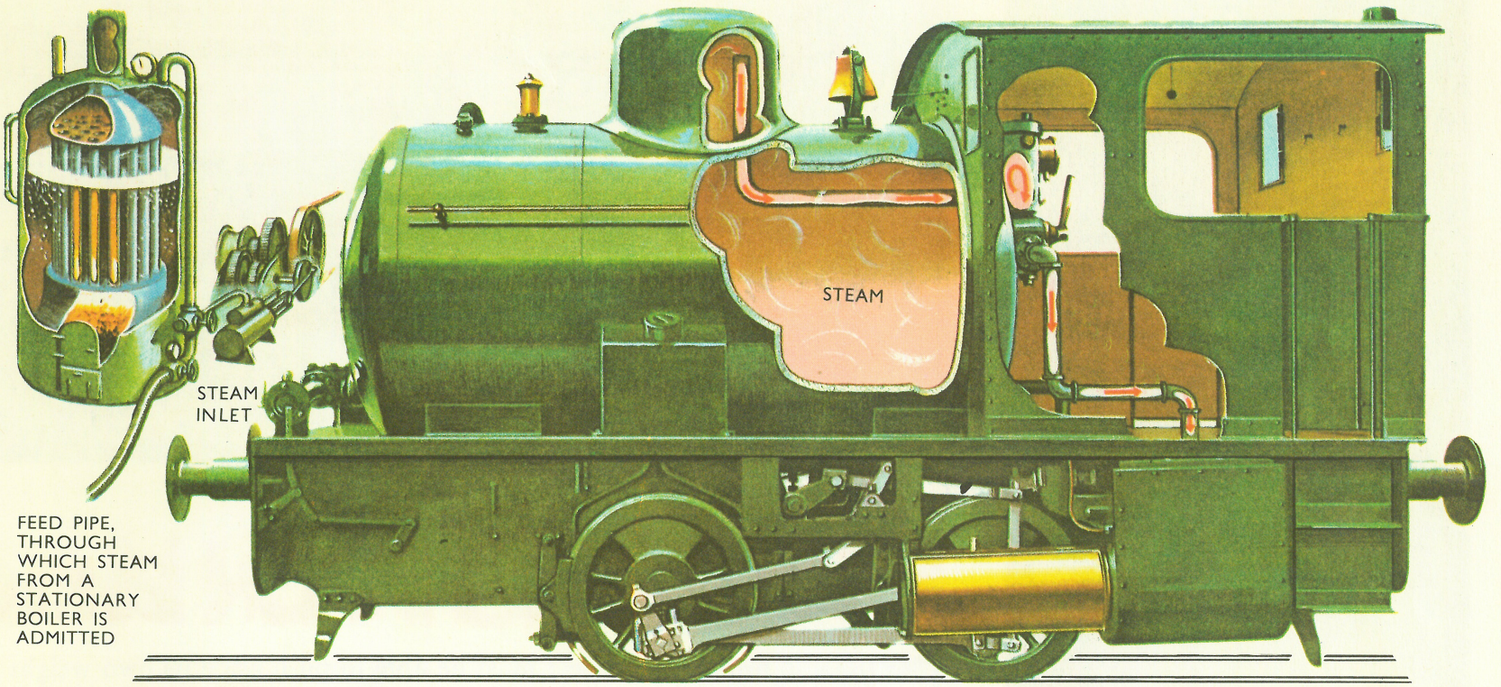


The path of water into the roots and up the stem to the leaves of a plant, and food movement from the leaves.

COVER PICTURE THEME: WATER
Distillation apparatus.

('*Water and Life on Earth*' *continued on inside back cover*)

The Fireless Locomotive



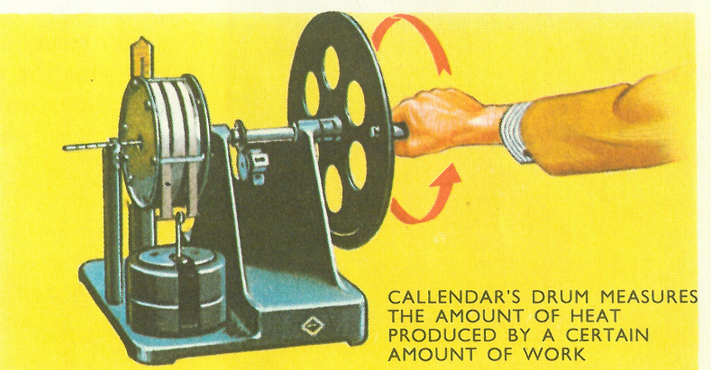
In a fireless locomotive mechanical energy is obtained from heat. The locomotive has no furnace or water-filled boiler of its own. Its sole source of energy is the heat stored in the steam which is transferred to it at intervals from a wayside boiler.

ENGINEERS are always very concerned about heat, for to do any sort of work heat must be used up. We use up heat every time we move. Because of the heat they store in their bodies warm-blooded animals can do much more work—and for longer periods—than cold-blooded creatures. Any amount of heat is the energy to do an amount of work. The connection between the heat of the furnace of this boiler and the energy that runs the donkey engine beside it is easily seen. The heat turns the water in the boiler into steam, expanding it many times. The steam is let into the cylinder and, by expanding more, pushes the piston to do the work of turning the wheel.

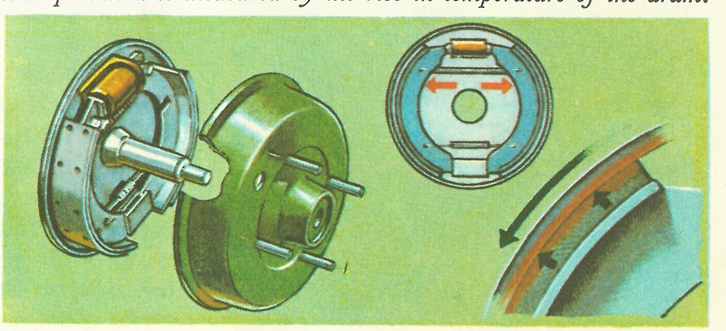
The energy of the heat of the steam continues to be available until it is used up in work. The odd-looking fireless locomotive has no furnace of its own. Its sole source of energy is a 'shot' of steam, piped from the wayside boiler.

On the energy stored in the steam the locomotive is able to do several hours hard shunting work. When the heat energy stored in its supply of steam has been nearly used up, the fireless locomotive must return for a new supply.

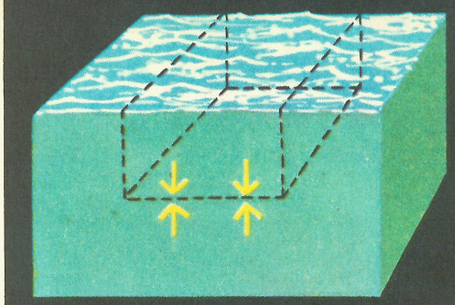
The conversion of heat energy to work holds true the other way round too; work produces heat. When the brakes of a car are put on, the brake-drums soon become hot (which is why the linings are made of a non-inflammable material, asbestos). The car engine does work to make the car move. When the brakes are put on this work is used up by the friction (rubbing) between the brake-shoes and the brake-drums and heat is produced.

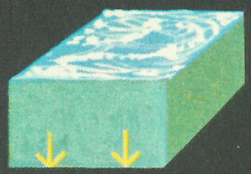


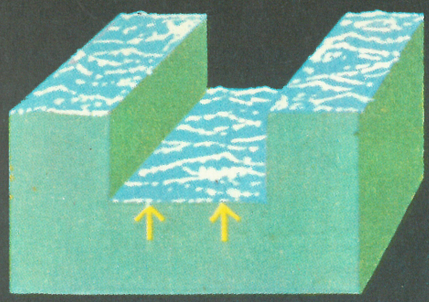
In Callendar's Drum the work of turning the handle is changed into heat as the moving drum rubs against a stationary belt. The heat produced is measured by the rise in temperature of the drum.

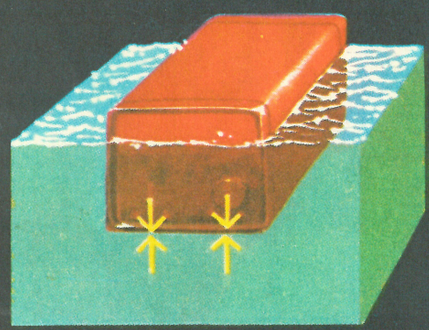


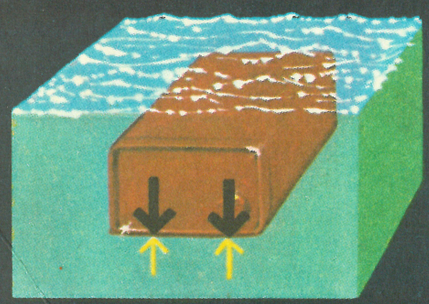
When jammed hard against the brake-drums of a fast-moving vehicle, brake-shoes start heating. The energy of the turning wheels is changed through friction (rubbing) between the moving drums and the stationary brake-shoes into heat.

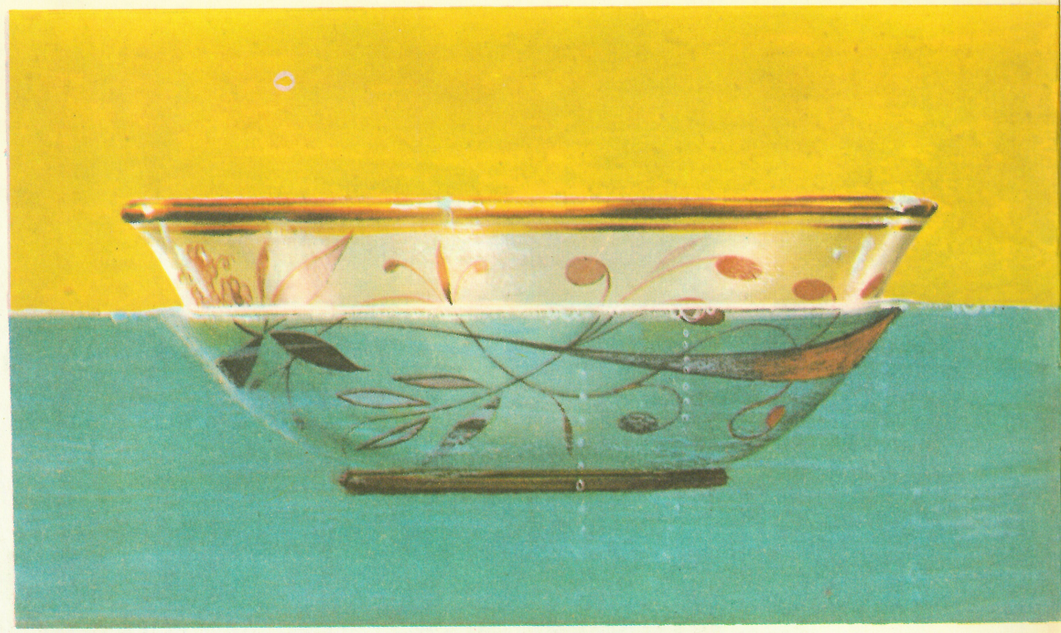












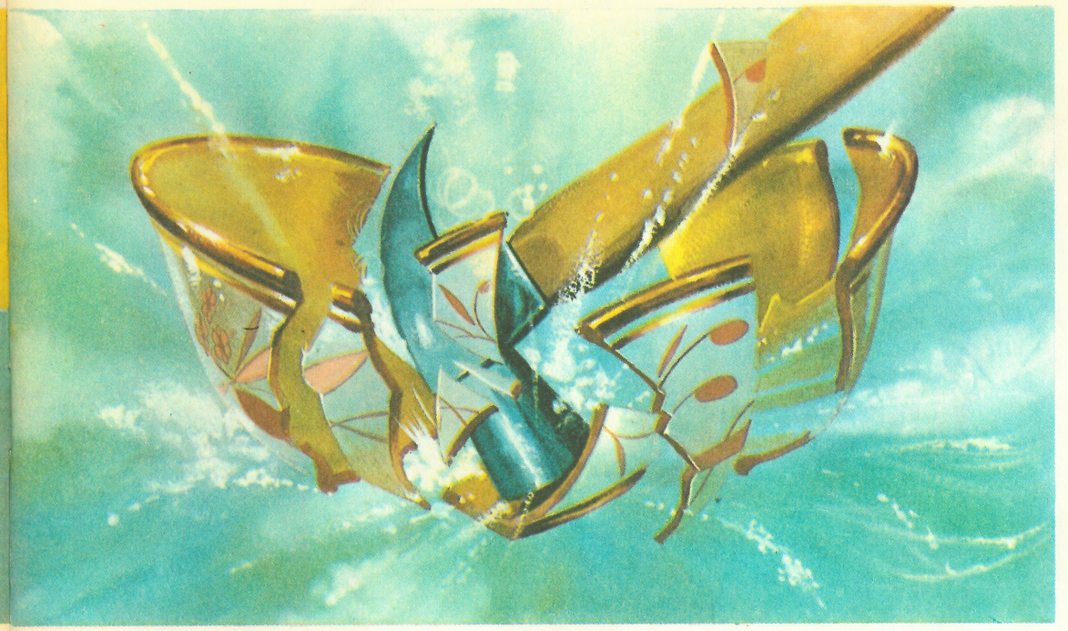
HYDROSTATICS

FLOATING and

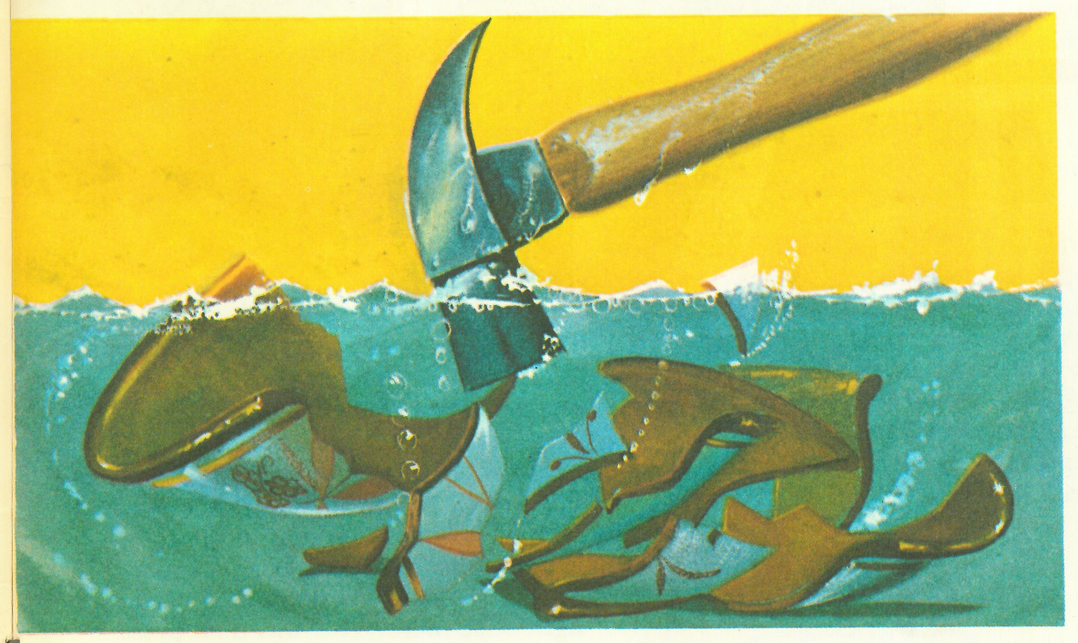
IN ORDER to float, an object must be able to push aside its own weight of water. The pictures on the left show that any 'block' of water floats because its weight acting downwards is balanced by an upward pressure. If you took away the block of water, the forces that had been holding it up would be available to support some other object of the *same* weight. They could easily support an empty petrol can because the weight of the metal can plus the air inside would be much less than a similar volume of water. But they could not support the same can filled with water, for the weight of the can *plus* the water inside would be greater than a similar volume of water. In other words, the upward force acting upon an object in water equals the weight of the water pushed aside, so the object must displace its own weight in water if it is to float. This idea was put forward by Archimedes, a Greek scientist, over 2,000 years ago.

A lump of metal will not float but the same piece of metal made into thin plates and shaped so that it will push aside a much larger amount of water (like the petrol can) will float. A ship is just a specially constructed tank, displacing enough water to float, even though it has to carry a cargo as well as its own weight. If, through some mishap, the ship begins to fill with water, it will become just like the water-filled petrol can. Through the added weight of the rising water the ship will sink lower and lower in order to displace more water to balance its increasing weight. Finally, when the weight of the ship and the water in it becomes more than the weight of the water it can displace, it will sink.

Steel ships, holed below the water line by an exploding torpedo or mine in time of war, as shown on the right, have been known to fill with water and sink in a matter of minutes. Wooden ships, on the other hand, have been known to remain afloat for a long time when holed and filled with water. The reason is that a log of timber normally contains tiny air-filled cavities between its fibres. Because of this, it is fairly bulky in proportion to its weight and, like the empty petrol can, is much lighter than a similar volume of water. When it is filled with water the weight of the ship plus the water inside is still less than the weight of a similar volume of water. It will just float lower in the water, displacing more water to balance its increased weight, just as a petrol can filled with petrol will float lower than



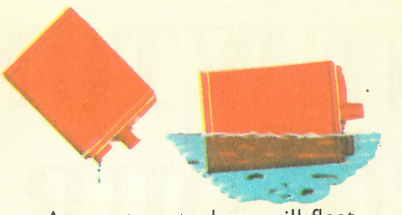
SINKING



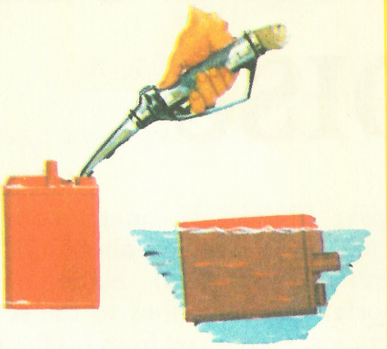
A china bowl will float because it will push aside its own weight in water. If the bowl were to be smashed, the pieces would sink. They would not be able to displace their own weight in water.

an empty petrol can. Eventually the ship will sink, for water gradually seeps in between the fibres of the wood and replaces the air held in the cavities until the weight of the water-filled and water-logged ship becomes greater than a similar amount of water.

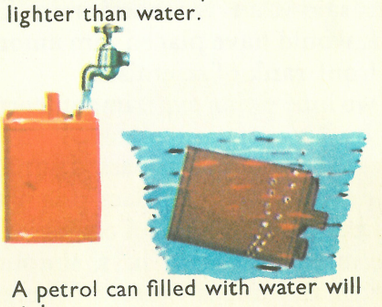
Some kinds of timber, such as ironwood and ebony, will not float at all. This is because the fibres in them are packed so closely that a log of the timber weighs more than a similar volume of water. On the other hand, balsa wood floats with very little of its volume submerged. It is so light, and its fibres so loosely packed, that it only needs to sink a little way into the water to push aside its own weight of water.



An empty petrol can will float.



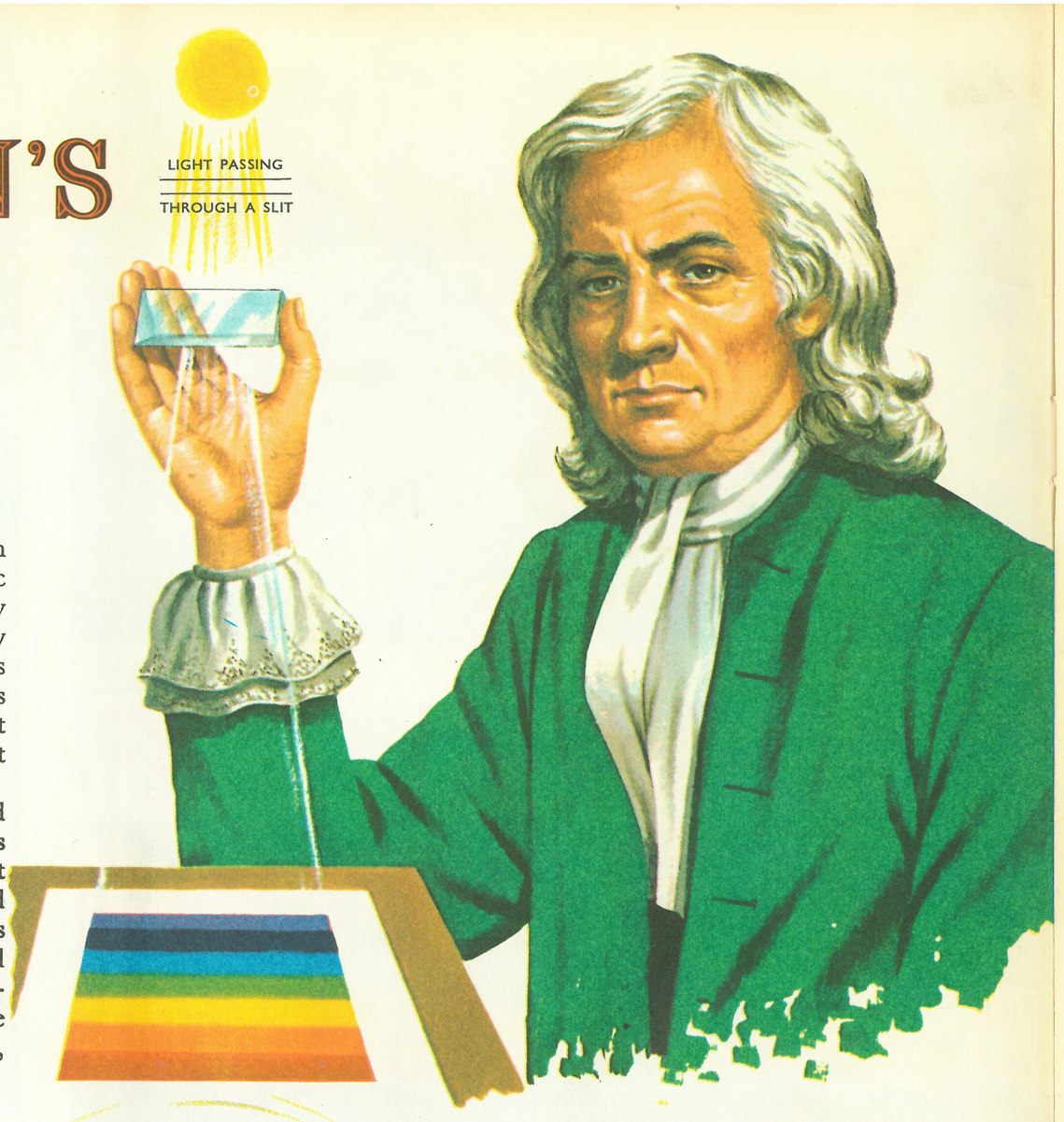
A petrol can filled with petrol will still float because petrol is much lighter than water.



A petrol can filled with water will sink.

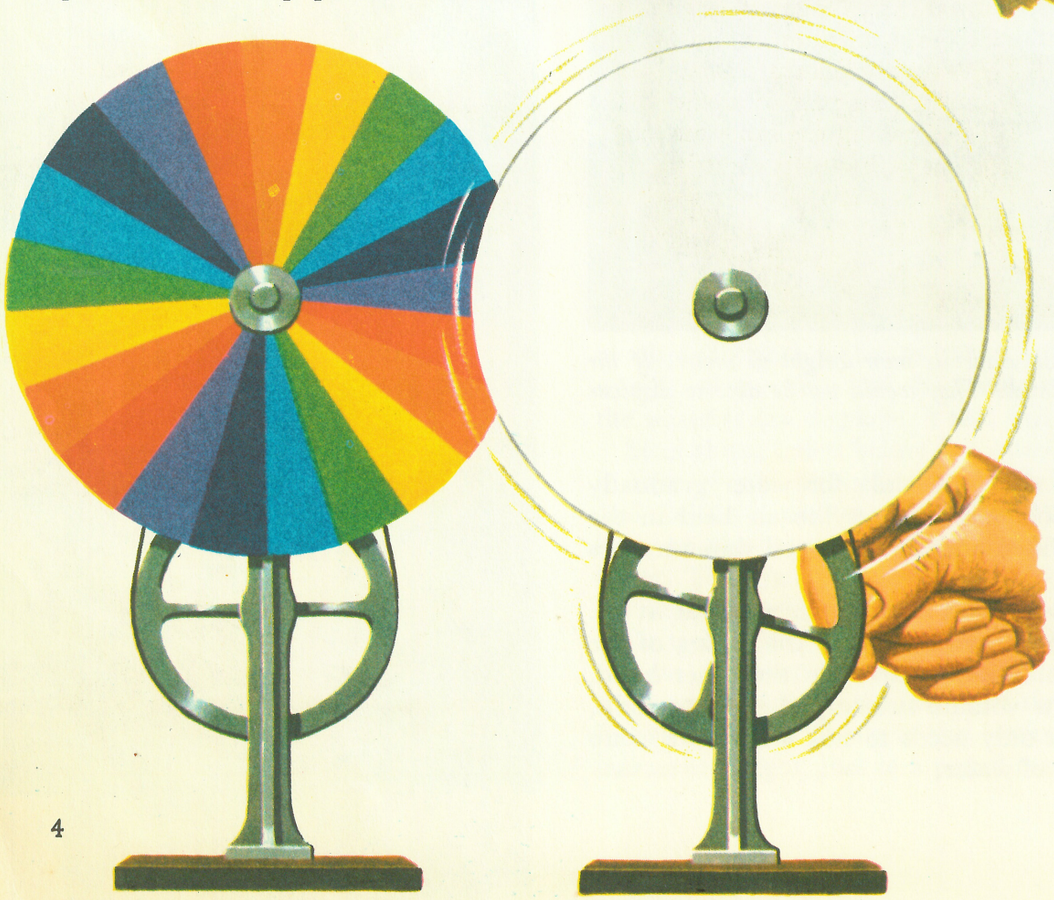
FAMOUS SCIENTISTS

NEWTON'S COLOUR DISC



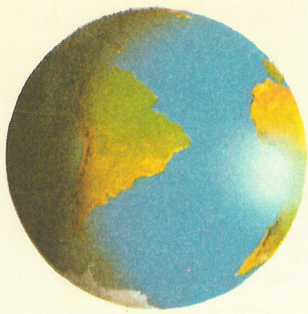
THE ENGLISH mathematician and natural philosopher Sir Isaac Newton (1642–1727) made many important contributions to the study of physics, even apart from his famous laws of motion and gravity. It has been said that his studies in light alone would have placed him amongst the front rank of scientists.

Two interesting experiments carried out by Newton are pictured on this page. About 1666 he passed sunlight through a triangular glass prism and obtained the spectrum of colours. This experiment is shown in a simplified form in the upper picture. The sunlight was dispersed (split up) by the prism into its component colours, spread out on the paper.

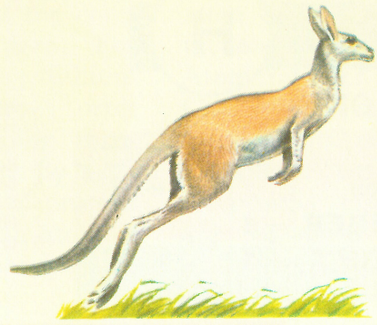


This is the same effect as in the rainbow (where the raindrops act as prisms). Although theories of the rainbow had been put forward at least half a century before this, Newton cleared up the subject by passing the spectrum back through another prism and producing white light once more. This was final proof that white light is made up of all the colours in the rainbow or spectrum.

Another experiment in the same field was carried out using a colour wheel (*lower picture*). This is a disc, painted in the colours of the spectrum, which can be spun round rapidly by turning a handle. The somewhat surprising result is that when it is turned rapidly, the disc apparently changes colour and becomes completely white. "White" light is thus shown to be made up of all the colours in the rainbow.

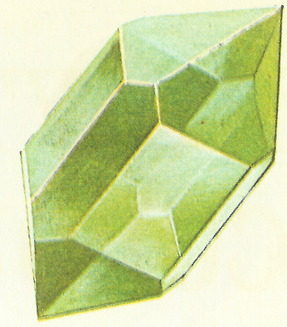


The EARTH is made of atoms



All LIVING CREATURES are made of atoms

All PLANTS are made of atoms



All NON-LIVING THINGS are made of atoms

ATOMS ARE THE SMALLEST POSSIBLE PIECES OF THE BASIC PURE MATERIALS THAT MAKE THE UNIVERSE

ATOMIC CHEMISTRY

EVERYTHING IS MADE OF ATOMS

—What are ATOMS Made of?

AT THE centre of every atom lies its core or *nucleus*. Around and at some distance from it, tiny particles called *electrons* circle the nucleus like planets circling the Sun. The electrons are held in orbit by the electrical attraction between their own negative charges and the positive charges on the nucleus. Each positive charge is carried by a particle called a *proton* that is roughly 1,840 times as heavy as an electron.

Atomic Number

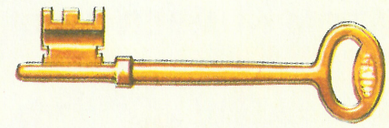
If we list the kinds of atoms in order of rank from the simplest to the most complicated, then the position of each in the list corresponds to the number of protons in its nucleus. This is called the *atomic number*.

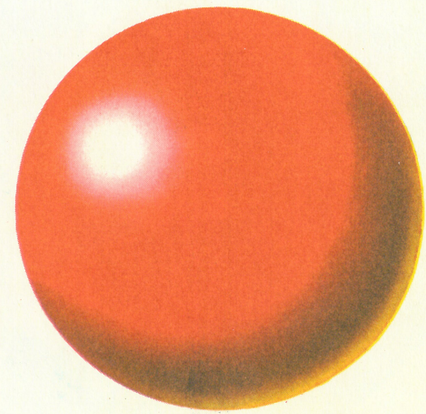
The number of protons in the nucleus should balance the number of electrons whirling round it. Thus the simplest atom, that of hydrogen (symbol H), consists of a single electron moving round a single proton. Atom number 2, that of helium (symbol He), has two protons in its nucleus, and two planetary electrons.

Atomic Weight

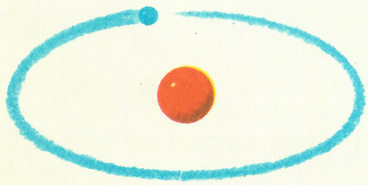
We might expect this atom (helium) to be twice as heavy as an atom of hydrogen, but experiments show that it is, in fact, four times as heavy. The extra heaviness (mass) is due to an additional pair of particles in the nucleus having the same mass as protons but without any electrical charge. These neutral particles are called *neutrons*.

Text continued on p. 7

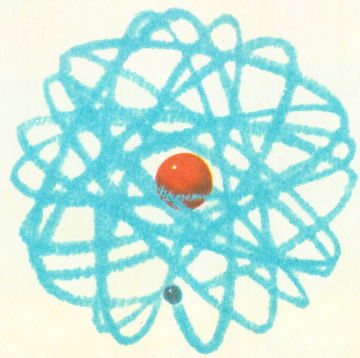




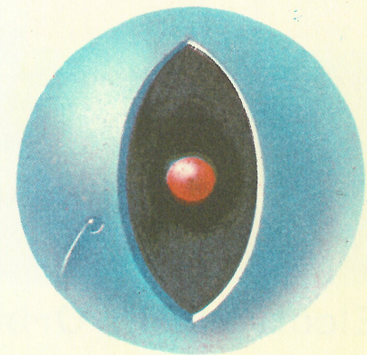
Atoms are so incredibly small that if the key shown here was expanded until it stretched 25,000 *miles right round the Earth each atom in the key would still be no larger than this red ball.*



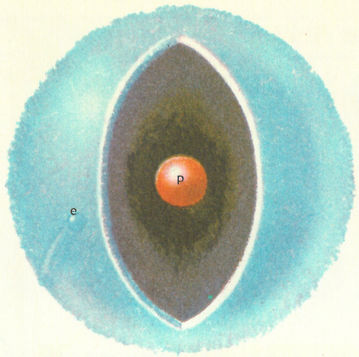
A hydrogen atom consists of a single electron moving round a single proton, like a planet in orbit round the Sun.



The orbit changes its position so rapidly that it seems to weave a solid shell round the nucleus.



Here the orbit is shown as a shell, but cut away to reveal the proton at the centre.



HYDROGEN H

ATOM NUMBER ONE

+ Protons		Electrons −
1 +	Balances	− 1

ATOM NUMBER = 1

ATOM WEIGHT = 1

The beginning of the list of Elements

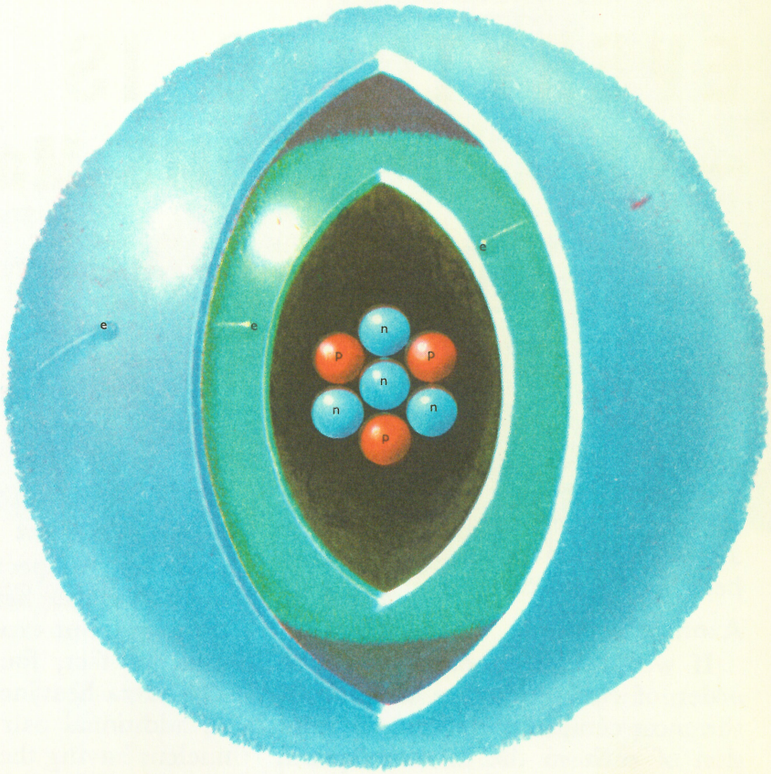
	Symbol	Atomic Number	Atomic Weight
1. Hydrogen	H	1	1
2. Helium	He	2	4
3. Lithium	Li	3	7
4. Beryllium	Be	4	9
5. Boron	B	5	11
6. Carbon	C	6	12
7. Nitrogen	N	7	14
8. Oxygen	O	8	16

There are 92 natural elements altogether.

You can check the Atomic Number and the Atomic Weight of each of these elements from the diagrams

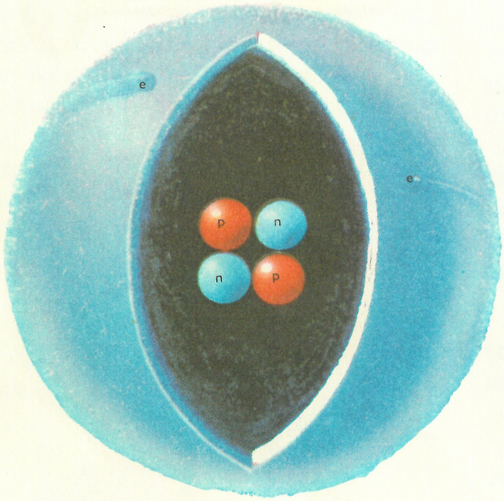
LITHIUM Li

ATOM NUMBER THREE



HELIUM He

ATOM NUMBER TWO



+ Protons		− Electrons
2 + +	Balances	− − 2

ATOM NUMBER = 2

Particles in Nucleus = Protons 2

Neutrons 2

ATOM WEIGHT = 4

2 Electrons in Orbit

THEY REMAIN THE SAME DISTANCE FROM THE NUCLEUS FORMING SHELL No. 1

+ Protons		Electrons −
3 + + +	Balances	− − − 3

ATOM NUMBER = 3

Particles in Nucleus = Protons 3

Neutrons 4

ATOM WEIGHT = 7

3 Electrons in Orbit

2 REMAIN IN INNER SHELL

1 FORMS SHELL No. 2

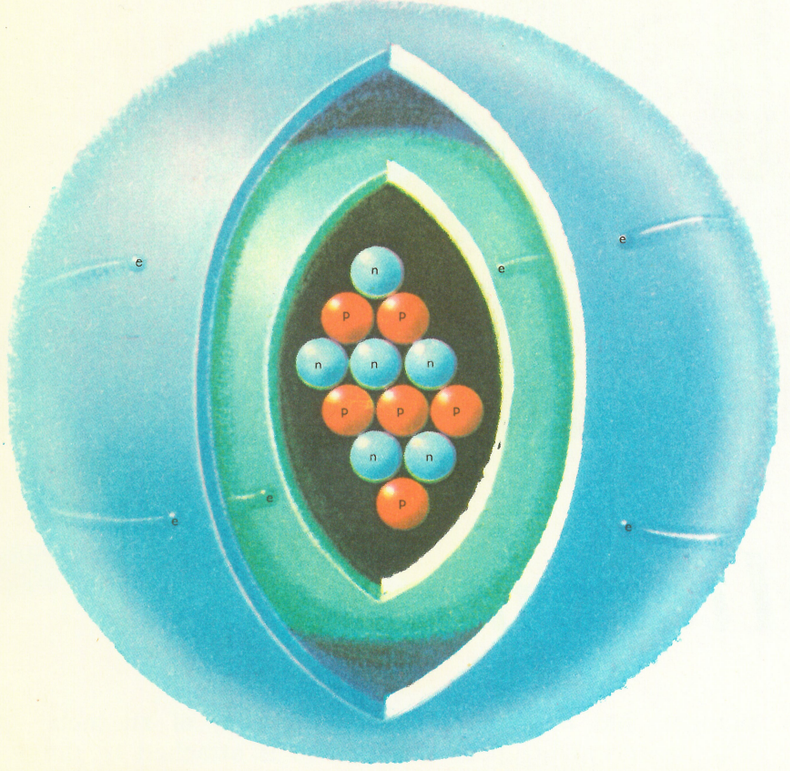
Neutrons are present in the cores of all atoms except hydrogen. For example, in atom number 3, lithium (symbol Li), three electrons orbit around a nucleus containing three protons and four neutrons. By adding up the total numbers of protons and neutrons we see that an atom of lithium is seven times as heavy as an atom of hydrogen. In other words, the *atomic weight* of lithium is seven. Atom number 6 is carbon (symbol C). Its nucleus is made up of six protons and six neutrons giving it an atomic weight of twelve. The six positive charges on the protons are balanced by six negatively charged electrons circling the nucleus.

Electron Shells

The electron orbits in every atom are arranged in a series of shells. The innermost shell can hold no more than two electrons and the second shell can hold no more than eight. The bigger atoms have more shells; these are described in a later article.

CARBON C

ATOM NUMBER SIX



+ Protons — Electrons −

6 + + + + + + Balances − − − − − − 6

ATOMIC NUMBER = 6

Particles in Nucleus = Protons 6

Neutrons 6

ATOMIC WEIGHT = 12

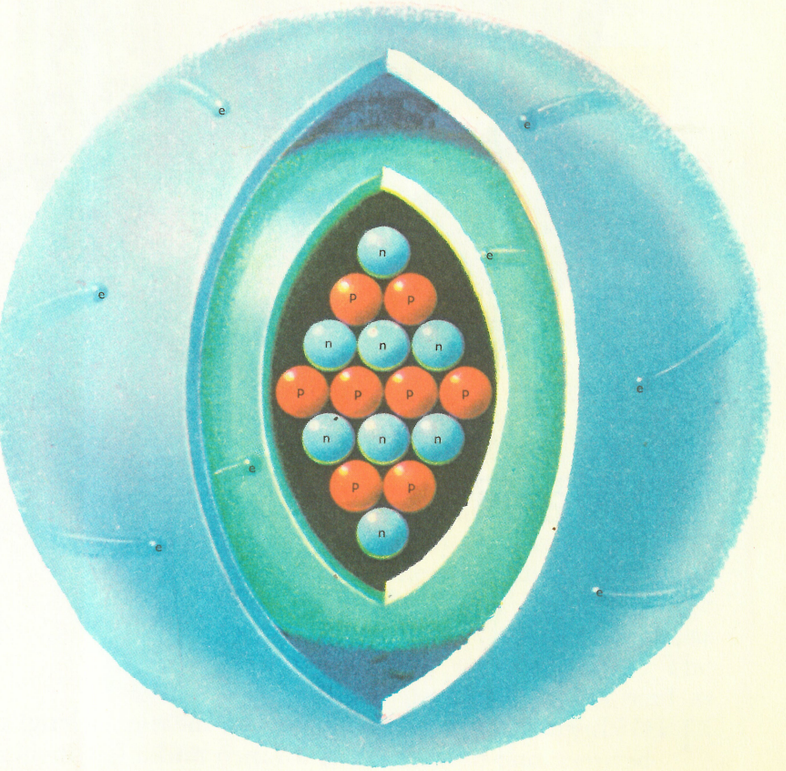
6 Electrons in Orbit

2 IN INNER SHELL

4 IN SHELL No. 2

OXYGEN O

ATOM NUMBER EIGHT



+ Protons — Electrons −

8 + + + + + + + + Balances − − − − − − − − 8

ATOMIC NUMBER = 8

Particles in Nucleus = Protons 8

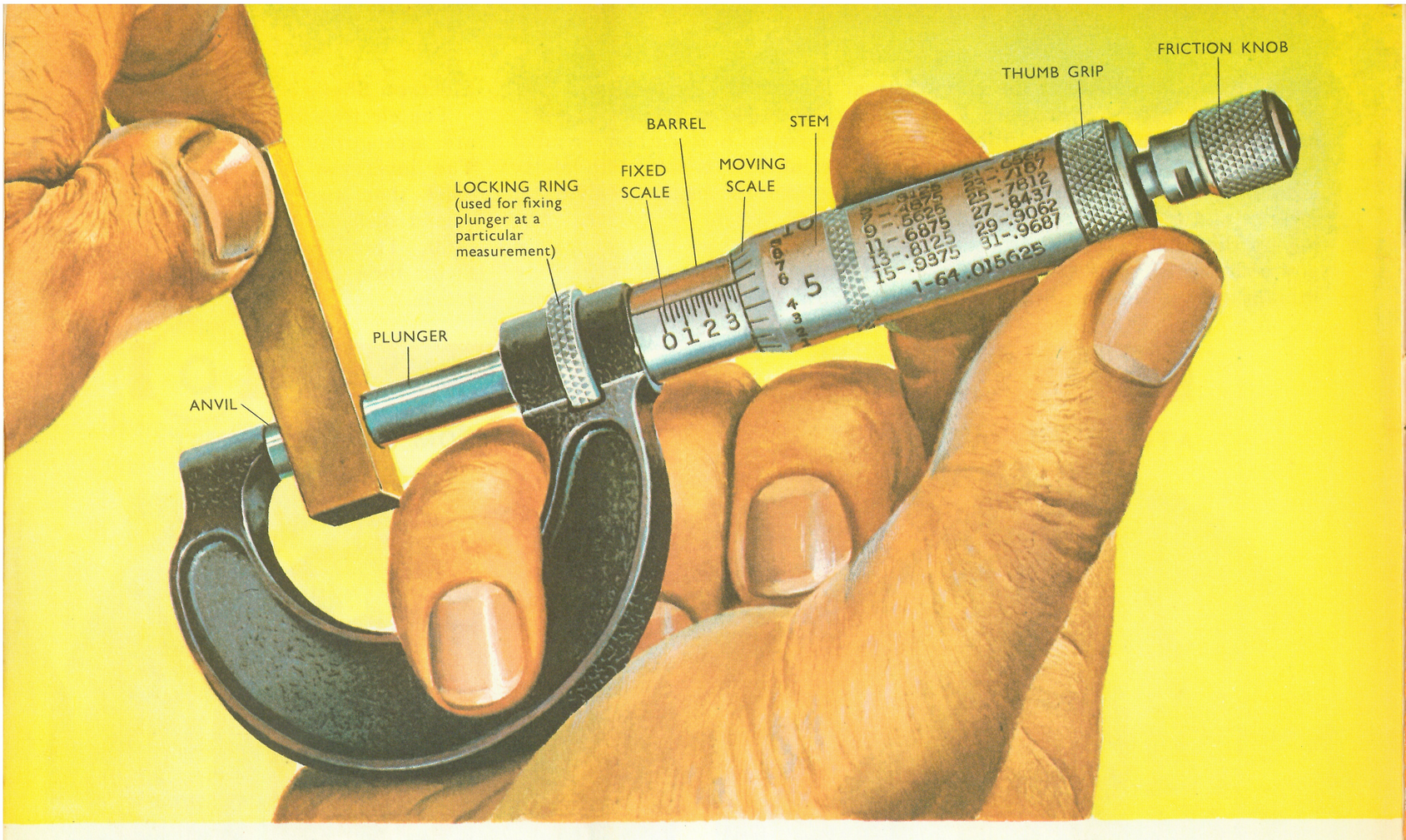
Neutrons 8

ATOMIC WEIGHT = 16

8 Electrons in Orbit

2 IN INNER SHELL

6 IN SHELL No. 2



TECHNOLOGY

Using a Micrometer

THIS instrument is commonly used for measuring lengths between one-thousandth of an inch and a few inches. With care it will give an accuracy of better than 1 part in a thousand. The type of micrometer (or, to give its full name 'micrometer screw gauge') illustrated here, is designed for the precise measurement of small thicknesses in engineering.

The object being measured is placed in the 'mouth' of the micrometer and the stem is rotated to screw out the plunger. When the object is firmly held between the plunger and the anvil, its thickness is read off directly from a scale cut into the 'barrel'—the inner part of the stem which does not rotate. Another set of numbers engraved on the bevelled edge of the stem and used in conjunction with the fixed scale gives readings to the nearest thousandth of an inch.

THE PRINCIPLE of the micrometer is simply that when any screw is turned through one complete rotation, it advances by an amount equal to its *pitch*, i.e. the distance between successive threads.

In the instrument illustrated above the screw thread (which is cut spirally around the concealed end of the plunger) has a pitch of $\frac{1}{40}$ (one-fortieth) of an inch. The outer moving part of the stem is attached to the plunger and turns with it. Because the stem is rather wide, any point on it moves through a distance of roughly $1\frac{1}{4}$ inches during a complete revolution. The plunger advances by only one-fortieth of an inch in a complete revolution so the movement of the stem is 50 times as great as the movement of the plunger. ($1\frac{1}{4}$ is equal to fifty-fortieths). The scales can be read like a ruler to the nearest twentieth of an inch, so a plunger movement of only one thousandth of an inch can, after it has been magnified 50 times by the screw, result in a readable movement of $\frac{1}{20}$ inch on the moving scale.

The accuracy of the instrument depends upon the precision with which its screw thread has been cut and cared for. The friction knob is a device which protects the thread from damage due to screwing the plunger too tightly against the anvil or the object being measured. As soon as the plunger meets the object or comes into contact with anything solid the friction knob slips round without turning the stem.

AN UNDERSTANDING SCIENCE POCKET HANDBOOK

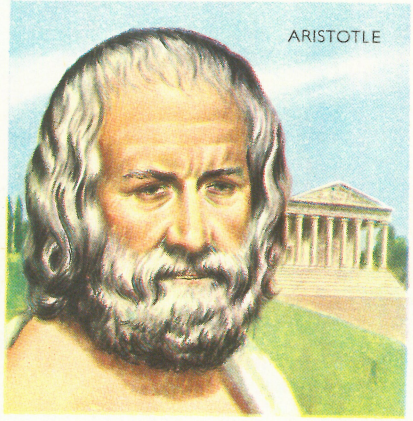
MEN OF SCIENCE

portraits of famous scientists of all ages presented to readers of Understanding Science

MEN OF SCIENCE

ADRIAN, LORD EDGAR (1889–) Britain, physiologist. Renowned for his work on the brain, the nervous system and the function of nerves.

AGASSIZ, JEAN LOUIS RODOLPHE (1807–1873) Switzerland, naturalist. An authority on fishes, for which he proposed a new classification. He also studied glaciers.



AMPÈRE, ANDRÉ-MARIE (1775–1836), France, mathematician. He studied electricity and magnetism. Gave his name to the unit of electric current.

APPLETON, SIR EDWARD VICTOR (1892–) Britain, physicist. Investigated the behaviour of long-distance radio waves, particularly their reflection in the upper atmosphere.

ARCHIMEDES (287–212 B.C.) Greece, mathematician. Stated Archimedes' principle, deduced the law of levers and invented the Archimedean screw and compound pulley.

ARISTOTLE (384–322 B.C.) Greece, philosopher. Made a classification of knowledge, and studied in the fields of meteorology, biology and geology.

ARRHENIUS, SVANTE AUGUST (1859–1927) Sweden, physicist. Investigated electrolytes, atmospheric electricity and problems relating to the structure of the universe.

ASTON, FRANCIS WILLIAM (1877–1945) Britain, physicist. Conducted important research into isotopes and developed an instrument known as the 'mass-spectrograph' to study them.

AVOGADRO, AMEDEO (1776–1856) Italy, physicist. Worked out the law which bears his name, stating that at the same pressure and temperature equal volumes of all gases contain the same number of molecules.

BACON, FRANCIS, LORD VERULAM (1561–1626) Britain, statesman and philosopher. Wrote important works on the state of knowledge and in particular the scientific approach to it. Insisted on the need for experiment and observation.

BACON, ROGER (*c.* 1214–1294) Britain, chemist and physicist. Sometimes thought to have discovered gunpowder. Carried out experiments in light, especially with lenses. Imprisoned because he was believed to be dealing in magic.

BAEKELAND, LEO HENDRIK (1863–1944) b. Belgium, chemist. Discovered first practical thermosetting resin. This led to production of Bakelite.

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BAEYER, JOHANN VON (1835–1917) Germany, chemist. Investigated indigo and uric acid compounds.

BANTING, SIR FREDERICK GRANT (1891–1941) Canada, physiologist. With Best, renowned as the discoverer of insulin, important in the treatment of diabetes.

BECQUEREL, ANTOINE HENRI (1852–1908) France, physicist. He discovered radioactivity while using uranium salts. Also studied phosphorescence, light and magnetism.

BERTHELOT, MARCELLIN (1827–1907) France, chemist. Expert on explosives. Demonstrated that organic compounds (e.g. fats and sugars) could be built up by ordinary chemical methods.

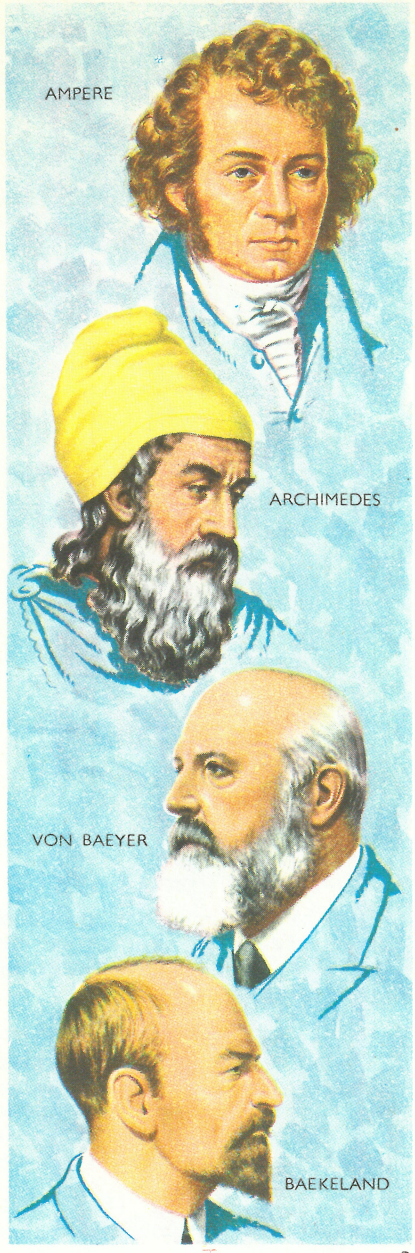
BERZELIUS, BARON JONS JAKOB (1779–1848) Sweden, chemist. Discovered a number of elements and suggested using the first letter of the elements as chemical symbols, and compiled the first accurate table of atomic weights.

BEST, CHARLES HERBERT (1899–) Canada, physiologist. With Banting discovered insulin, used for treating diabetics.

BLACK, JOSEPH (1728–1799) Britain, chemist. Rediscovered carbon dioxide, which he called 'fixed air'. He is also noted for his theories of latent and specific heat.

BLACKETT, PATRICK MAYNARD STUART (1897–) Britain, physicist. With the cloud chamber he photographed the splitting of a nitrogen nucleus by an alpha particle into a proton and oxygen nucleus.

BOHR, NIELS (1885–) Denmark, physicist. Greatly extended the theory of atomic structure by devising a



method of explaining the spectra of elements and their position on the periodic table. He helped to develop the quantum theory.

Boussingault, Jean Baptiste (1807–1887) France, biologist. He explained the basic differences between animal and plant nutrition and showed that plants obtain nitrogen from nitrates in the soil and not from the atmosphere.

Boyle, Hon. Robert (1627–1691) Britain, chemist. Outstanding figure in 17th-century chemistry. His investigations covered a wide field including pneumatics; he is best remembered for the law named after him.

Bradley, James (1693–1762) Britain, astronomer. Measured speed of light and stated the laws of refraction of light.

Bragg, Sir William Henry (1862–1942) Britain, physicist. Famous for his work on the structure of crystals and of atoms, using the X-ray spectrograph, which he and his son, W. L. Bragg, developed together.

Bragg, Sir William Lawrence (1890–) Britain, physicist. Made important investigations into the regular spacing of atoms in crystals.

Brahe, Tycho (1546–1601) Denmark, astronomer. He made many accurate observations on the planets and the Sun. These formed the basis of Kepler's Laws.

Brown, Robert (1773–1858) Britain, botanist. Was the first to observe the movements of particles suspended in a liquid. This is called Brownian movement after him.

Buffon, Georges Louis (1707–1788) France, naturalist. Devoted his life to describing and classifying plants. Noted for his monumental work, *Histoire Naturelle*.

Bunsen, Robert Wilhelm Eberhard (1811–1899) Germany, chemist. With Kirchhoff he discovered spectrum analysis. He is remembered for his invention of the bunsen burner, though he made more important inventions and discoveries.

Burbank, Luther (1849–1926) U.S.A., biologist. Experimented in plant breeding, producing improved strains of plums, tomatoes, etc.

Cannizzaro, Stanislao (1826–1910) Italy, chemist. Applied Avogadro's Hypothesis to the determination of atomic weights; experimented in organic chemistry and was responsible for the reaction named after him.

Carothers, Wallace Hume (1896–1937) U.S.A., chemist. Expert on plastics, developed nylon.

Cavendish, Henry (1731–1810) Britain, physicist and chemist. Discovered hydrogen and showed that water is produced when hydrogen is burnt. Made the first accurate determination of the weight of the Earth.

Chadwick, Sir James (1891–) Britain, physicist. Worked on nuclear disintegration and the scattering of alpha particles. Bombarding beryllium with alpha particles led to his discovery of the neutron.

Charles, Jacques (1746–1823) France, physicist. Produced Charles' Law, which explains the connection between the expansion of a gas and a rise in its temperature.

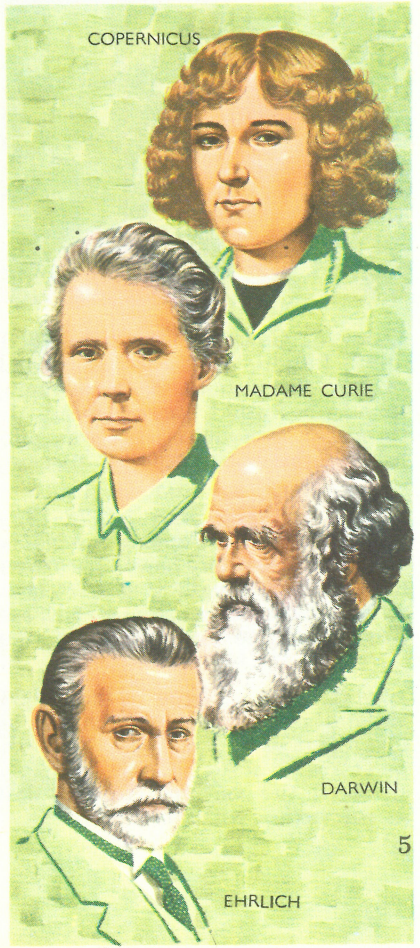
Cockcroft, Sir John Douglas (1897–) Britain, physicist. He worked on the transmutation of atomic nuclei using accelerated atomic particles. Succeeded in splitting lithium nucleus using high-speed protons.

Copernicus, Nicolaus (1473–1543) Poland, astronomer. Discovered that the Sun is the centre of the solar system. He realised that the stars were a vast distance from the Earth but thought they were fixed to a sphere.

Crookes, Sir William (1832–1919) Britain, chemist and physicist. Invented Crookes' vacuum tube and suggested the true nature of cathode rays. Discovered thallium and studied radioactivity.

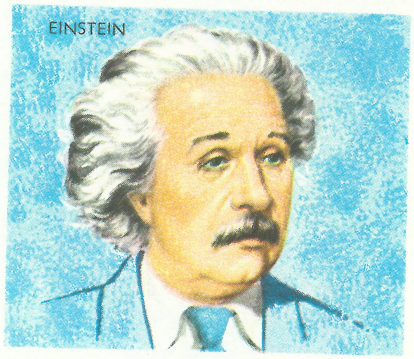
Curie, Marie Sklodowska (1867–1934) b. Poland, settled France, chemist. With her husband she separated polonium from uranium minerals and later discovered radium.

Curie, Pierre (1859–1906) France, physicist and chemist. He worked on crystallography, magnetism and piezoelectricity. Helped to discover radium and polonium.



CUVIER, BARON GEORGES LÉOPOLD (1769–1832) France, naturalist. Worked on comparative anatomy and proposed a complete classification of the animal kingdom. Founded palaeontology as a separate subject.

DALTON, JOHN (1766–1844) Britain, chemist. Put forward his famous atomic theory of matter from which modern chemistry has developed.



DARWIN, CHARLES ROBERT (1809–1882) Britain, naturalist. As a result of his observations while voyaging round the world he advanced the theory of evolution. This was published in his book *Origin of Species*.

DAVY, SIR HUMPHRY (1778–1829) Britain, chemist. Famous for his invention of the safety lamp. He experimented with laughing gas, isolated sodium and other reactive metals, and was responsible for naming chlorine.

DEWAR, SIR JAMES (1842–1923) Britain, chemist. Important for his investigations of matter at low temperatures; first to liquefy hydrogen. Invented the vacuum (Dewar) flask in connection with his work.

DOMAGK, GERHARD (1895–) Germany, biochemist. Began the development of the important family of drugs related to sulphanilamide.

DOPPLER, CHRISTIAN (1803–1853) Austria, physicist. Discovered the effect which bears his name, that sound and light from a moving object alter their frequencies to an observer as the object approaches or moves away from him.

EDDINGTON, SIR ARTHUR STANLEY (1882–1944) Britain, chemist. Made notable contributions to astrophysics, especially on the structure of stars, and calculated the age of the Sun.

EHRLICH, PAUL (1854–1915) Germany, bacteriologist. Discovered that dyes are selectively absorbed by microbes. By combining dyes with poisonous chemicals he tried to kill harmful microbes.

EINSTEIN, ALBERT (1879–1955) b. Germany, mathematical physicist. Wrote *General Theory of Relativity*, revising fundamental ideas of gravitation relating mass to energy, and showing that space and time were inseparable concepts. He has done valuable work on the quantum theory.

EUCLID (*c.* 330–275 B.C.) Greece, mathematician. Wrote important text books on geometry which are still used today.

FABRE, JEAN HENRI (1823–1915) France, naturalist. Wrote many books based on his observations of insect life.

FAHRENHEIT, GABRIEL DANIEL (1686–1736) Germany, physicist. Famous for his temperature scale which is still used occasionally.

FARADAY, MICHAEL (1791–1867) Britain, physicist and chemist. Discovered the principle of electro-magnetic induction used in the dynamo. Also liquefied chlorine and formulated laws of electrolysis.

FERMI, ENRICO (1901–1954) Italy, physicist. Made notable contributions to nuclear physics by his work on artificial radioactive substances and atomic energy.

FISCHER, EMIL HERMANN (1852–1919) Germany, chemist. Worked for many years on the structure of carbohydrates and proteins. He built up artificially a number of naturally occurring substances such as fructose and caffeine.

FLAMSTEED, JOHN (1646–1719) Britain, astronomer. The first Astronomer Royal, he is famous for his invention of the conical map-projection and made many advances in improving methods of observing stars

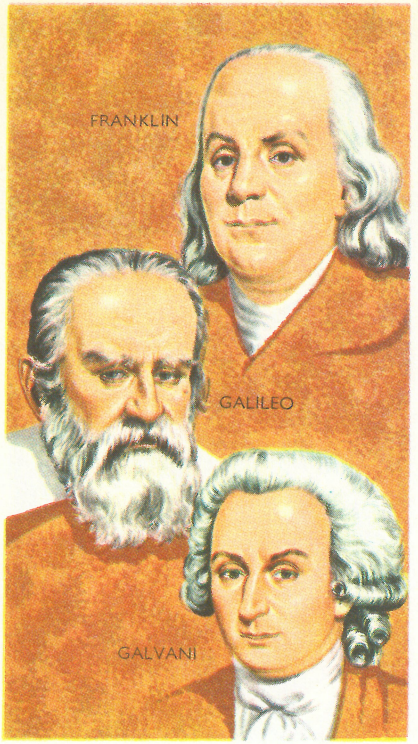
FLEMING, SIR ALEXANDER (1881–1955) Britain, bacteriologist. Renowned for his discovery of penicillin.

FLOREY, SIR HOWARD WALTER (1889–) Britain, pathologist. With Chain, isolated a pure and stable form of penicillin which was suitable for medical purposes.

FRANKLIN, BENJAMIN (1706–1790) U.S.A. Statesman and physicist. He was the first to prove the electrical nature of lightning and invented the lightning conductor.

FRAUNHOFER, JOSEPH VON (1787–1826) Germany, physicist. His was the first precise study of the dark lines in the Sun's spectrum called Fraunhofer lines.

FREUD, SIGMUND (1856–1939) Austria, psychologist. Pioneer of the modern approach to psychology, famous for realising the importance of unconscious thoughts and feelings on our behaviour.



GALEN, CLAUDIUS (about 130–200) Greece, physician; prolific author on anatomy and physiology. His works remained standard for many years.

GALILEI, GALILEO (1564–1642) Italy, mathematician and astronomer. Made the first practical astronomical telescope with which he studied the moon's surface and the Milky Way, the Sun and many of the planets.

GALTON, SIR FRANCIS (1822–1911) Britain, anthropologist. Made early statistical studies of the way different factors are inherited.

GALVANI, LUIGI (1737–1798) Italy, physicist. Renowned for his discovery of animal electricity (galvanism). By touching the nerve leading to a muscle in a frog's leg he showed that the muscle contracts.

GAUSS, KARL FRIEDRICH (1777–1855) Germany, mathematician. Established a great reputation for his work on the theory of magnetism and the theory of numbers.

GAY-LUSSAC, JOSEPH LOUIS (1778–(1850) France, chemist and physicist. Noted for his Law of Combining Volumes, and for his other advances in chemistry.

GEBER (*c.* 721–813) Arabia, alchemist. Early writer on chemical methods. Described the preparation of nitric acid and many other substances.

GILBERT, WILLIAM (1544–1603) Britain, physician. The father of magnetism, he discovered the basic law of magnetism, i.e. that like poles repel. He realised that the Earth itself acted as a magnet.

GOLGI, CAMILLO (1843–1926) Italy, histologist. Discovered the Golgi apparatus, a fibrous network in most cells, devised many staining techniques for studying the structure of the nervous system.

GRAHAM, THOMAS (1805–1869) Britain, chemist. Famous for his work on the diffusion of gases. Formulated Graham's Law.

GUERICKE, OTTO VON (1602–1686) Germany, physicist. He invented the air pump, and succeeded in creating a vacuum, and invented a machine for producing electricity by applying friction to a sulphur ball.

HAECKEL, ERNST HEINRICH (1834–1919) Germany, biologist. He supported Darwin's theory and made important studies on jellyfishes, corals and sponges. He made the first attempt to draw a genealogical tree of the animal kingdom.

HALLEY, EDMUND (1656–1742) Britain, astronomer. Best known for his observation of Halley's Comet, Halley also worked on the Earth's magnetism, winds and the movement of stars.

HARVEY, WILLIAM (1578–1657) Britain, physician. Achieved fame through his discovery of the circulation of the blood.

A

Prospectus

OF THE MATERIAL

Understanding SCIENCE

WILL PRESENT
TO ITS READERS
IN SUCCESSIVE ISSUES

introduction

Week by week UNDERSTANDING SCIENCE will present a balanced and varied selection of articles, each one of which is a carefully planned member of a family of articles—a complete outline of a particular science. Each science has its own series of articles. There is an unmatchable satisfaction in exploring each of them, so that the field it covers becomes familiar personal knowledge. Some contain numerous articles, some only a handful. The articles in all the outlines have been so arranged as to dovetail together as they appear in weekly issues. It is impossible to give in this small brochure more than a hint of the range of subjects covered in each course, or the care that has been taken to make each article stand on its own as an easily understood and memorable explanation of its point. Typical subjects have been quoted to give a few indications of the interest that is aroused by the treatment.

UNDERSTANDING SCIENCE BECOMES A STUDY-AID ENCYCLOPAEDIA

All the courses follow as closely as possible the conventional order of teaching the science subjects, and students have in the regular articles a splendid background to normal studies. It is sure to awaken extra interest and enthusiasm. The first-class colour illustrations incorporate many visual aids devised by the editors. The use of colour also for conventional diagrams and pictorial examples makes these remarkably easier to remember. In fact UNDERSTANDING SCIENCE *gives students a new tool to assist their every-day familiarity with each basic scientific idea.*

the General Science group

THE COVER ARTICLES

These are planned as features to be printed on front and back cover pages and the cover design introduces the theme of the article.

There are various types of articles; generally they fall into the following categories:

1. An outline of the scientific facts and scientific significance of some familiar feature of life—e.g. oil, water, time, washing, fire, the petrol engine, the atmosphere.
2. A basic outline of a whole field of science, normally already covered in one or more series of articles, but here condensed and seen as a convenient whole—e.g. hydraulics, electric power, gravity, insect life, acids, the growth of plants, ballistics, nitrogen and life.
3. The work of scientists of a particular kind—e.g. nuclear research, aerodynamics, biochemistry.
4. Specially interesting subjects here given expanded treatment—e.g. the midnight sun, radar, crystals and the spectroscope, sound reproduction, numbers and calculators, pollination.
5. Landmarks in the progress of science—e.g. the invention of radio, the exploration of the atom, the vanquishing of dread diseases. Also the work of famous scientists—e.g. famous biologists, famous physicists, famous astronomers, the discoverers of the elements, electrical discoveries.

FAMOUS SCIENTIFIC ACHIEVEMENTS

These articles each feature one scientist with brief biographical details and concentration upon a very clear explanation of his most famous experiment or hypothesis—this supplements the regular articles on the particular science involved—e.g. Guericke and his vacuum spheres, Kepler and his laws about planets, Lavoisier and his experiments in the chemistry of burning, Bragg and his use of X-rays to investigate the structure of crystals.

the Chemistry group

So much of modern technology stems from the Chemical Sciences, as well as much of medicine and biology, that Chemistry has been presented as six parallel outlines which together build up a remarkably complete account of elementary chemistry, but which can each be taken singly as a very helpful introduction to its particular field. The use of the most modern approach to the teaching of chemistry gives these studies the zest and interest of a game.

OUTLINE OF ATOMIC CHEMISTRY—the structure of atoms; that is, the reason for their behaviour, their different weights, and their combinations. The articles present the basic pattern of chemistry. Some articles: *Atoms in Partnership, The Weight of One Atom, Givers and Takers—Valency, Splitting a Diamond.*

OUTLINE OF CHEMICAL REACTIONS—the different types of reaction progressively presented for clarity and easy memorising.

OUTLINE OF CHEMICAL COMPOUNDS. Commencing with *The Families of Natural Elements*, an ingenious picture of the Periodic Table that sets the stage for the grouping of elements, each one of this series of articles describes a group of elements with the practical uses of the properties they share. Starting with *Oxygen and Oxides* some of the following articles are *The Halogens, Acids, Inert Gases, Silver and Gold, The Rare Earths.*

Outline of Organic Chemistry. The modern giant field of chemistry which includes oil, soap and plastics. Some articles: *Why Do Dyes Have Their Colour?*, *Explosives*, *Soap Making*, *Carbon Chains—Candles to Jet Fuels*.

Outline of Chemical Analysis. A small group of articles to describe analytical tests, both qualitative and quantitative.

Industrial Chemistry. The commercial practice in some of the leading chemical industries; the methods used are compared with the laboratory approach found in *Chemical Compounds*.

the Biological Sciences group

These sciences which involve living things make some of the most absorbing subjects to interest the ordinary reader, though the longer outlines (Biology and Physiology) are primarily planned for those who wish to follow the normal course of study of these subjects; the rest of the outlines are designed for general interest.

An Outline of Biology. This outline and that on Physiology are complementary and articles from each are planned to alternate in successive issues of Understanding Science. The form and life of all types of plants and animals are traced, from protoplasm and the cell, genetics, nutrition and the senses, to reproduction. Some articles: *Why a Plant Needs Water*, *Sex-linked Chickens*, *They Hear Through Their Feet*, *The Depth Control of a Fish*.

An Outline of Ecology. The interdependence of creatures living in the same area. There is one short series of articles concerning sea life, another on land life. Typical article: *Pastures of the Sea*.

An Outline of Physiology and Anatomy. The processes of living (Physiology) in this outline has been linked with the structure of the body (Anatomy). The overall theme is the comparison of both the anatomy and the physiology of a number of creatures, invertebrate and vertebrate, one of them being man. Some articles: *Is a Skeleton Necessary? Regeneration—Animals which can Grow New Limbs*, *Insect Muscles*, *The Operation of Muscles by Nerves*, *Three-chambered Hearts*.

An Outline of Medicine. In a series of articles that present the bases of various branches of medicine. Some articles: *The Problems of Tropical Medicine*, *Disease Organisms*, *Anaesthetics*.

Applied Biology. The practical use of biological knowledge and techniques in research and in wider fields. Some articles: *Breeding Cattle*, *Hybridisation*, *Embryology*.

Veterinary Science. Articles on research and everyday practice in animal care and nutrition, and animal diseases.

An Outline of Agricultural Science. The techniques used in the many branches of today's advanced agriculture, and the principles that underlie them.

Anthropology. The development of man as a social creature, and the distribution of races.

An Outline of Psychology. The essentials of this developing science.

the Technology group

The Use of Instruments. A detailed practical description of the proper use and care of types of scientific equipment that are required in sufficiently wide fields to justify this treatment. The subjects range from a Chemical Balance to a Cathode Ray Oscilloscope, from an Ammeter to a Theodolite, from a pH Meter to a Phase Contrast Microscope. An outline of the principle of the instrument is given, though there are often more extended descriptions in other sections (e.g. Cathode Ray Oscilloscope in Electronics, Sextant in Optics).

Technology. These articles range over a very wide field. It is intended that they shall appear, generally, *after* the basic scientific principles involved have been covered in the 'educational science' courses (Physics, Chemistry). The articles can be roughly classified as Techniques (e.g. developing films, recharging accumulators, welding); Skills (e.g. lens grinding, reading an engineering drawing); Processes used in a Specific Industry (e.g. wool industry, shipbuilding, mining); Equipment used in Many Industries (e.g. servo-mechanisms, 'magic eye' controls, infra-red, pneumatic tools, ultrasonics); Special Production Methods (e.g. processing nuclear fuels, enamel and stoving, bleaching).

Applied Science. Modern uses of scientific principles. From range finders and forensic medicine to cable relays and vaccine manufacture, water softening to colour films.

Engineering. The basic principles and practical examples.

the Elementary Physics group

Most of the basic laws of the universe fall among the principles of physics and they govern innumerable factors in our mechanised world. But for most people it is not at all easy to carry these in one's head so that they can be applied to everyday practical things. The editors of Understanding Science have planned the articles on these normally dull-sounding laws to have a visual impact that makes them vividly clear and at once part of one's ordinary knowledge of the nature of the surrounding world. The outlines given in Understanding Science are divided into three groups:

Outline of Organic Chemistry. The modern giant field of chemistry which includes oil, soap and plastics. Some articles: *Why Do Dyes Have Their Colour?, Explosives, Soap Making, Carbon Chains—Candles to Jet Fuels.*

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An Outline of Psychology. The essentials of this developing science.

the Technology group

The Use of Instruments. A detailed practical description of the proper use and care of types of scientific equipment that are required in sufficiently wide fields to justify this treatment. The subjects range from a Chemical Balance to a Cathode Ray Oscilloscope, from an Ammeter to a Theodolite, from a pH Meter to a Phase Contrast Microscope. An outline of the principle of the instrument is given, though there are often more extended descriptions in other sections (e.g. Cathode Ray Oscilloscope in Electronics, Sextant in Optics).

Technology. These articles range over a very wide field. It is intended that they shall appear, generally, *after* the basic scientific principles involved have been covered in the 'educational science' courses (Physics, Chemistry). The articles can be roughly classified as Techniques (e.g. developing films, recharging accumulators, welding); Skills (e.g. lens grinding, reading an engineering drawing); Processes used in a Specific Industry (e.g. wool industry, shipbuilding, mining); Equipment used in Many Industries (e.g. servo-mechanisms, 'magic eye' controls, infra-red, pneumatic tools, ultrasonics); Special Production Methods (e.g. processing nuclear fuels, enamel and stoving, bleaching).

Applied Science. Modern uses of scientific principles. From range finders and forensic medicine to cable relays and vaccine manufacture, water softening to colour films.

Engineering. The basic principles and practical examples.

the Elementary Physics group

Most of the basic laws of the universe fall among the principles of physics and they govern innumerable factors in our mechanised world. But for most people it is not at all easy to carry these in one's head so that they can be applied to everyday practical things. The editors of Understanding Science have planned the articles on these normally dull-sounding laws to have a visual impact that makes them vividly clear and at once part of one's ordinary knowledge of the nature of the surrounding world. The outlines given in Understanding Science are divided into three groups:

AN OUTLINE OF SIMPLE PHYSICS

There is a course on HEAT PHYSICS. Car, steam and jet engines, thermostats, refrigerators, expansion, conduction, convection, radiation, latent and specific heat are among the subjects covered. Some articles: *Survival Suits, Rocket Fuels, The Thermal Efficiency of Locomotives, Absolute Zero.*

Another course, on OPTICS, deals with photography, telescopes and microscopes and the elementary aspects of light, and takes the reader through to fluorescence, infra-red, and polarization. Some articles: *Mirages, The Magic of Mirrors.*

The SOUND course deals with the basic sound laws, and extends to cover such subjects as the ear, acoustics and ultrasonics. Typical articles: *Musical Instruments, Sound Waves, Pushing the Swing, Resonance.*

The HYDROSTATICS course is mostly about pressure in liquids and gases; Archimedes' principle, aerofoils and wind-tunnels, and Bernoulli's principle are also included. Articles: *What Went Wrong with the* Titanic?, *Aircraft Undercarriages, Hydro-electric Dams.*

AN OUTLINE OF MECHANICS

The forces that control the matter of which the universe is made are defined in the various physical sciences generally known as Mechanics.

The DYNAMICS course gives practical demonstrations of the laws of motion, gravity, centrifugal force. Some articles: *Safety Straps for Motorists, The Gyroscope Always Stays Put, Crack Shots and Rifle Sights.*

PROPERTIES OF MATTER. Some articles: *Why Damp Rises Up a Wall* (surface tension), *The Three States of Matter*. The course explains the fundamentals of density, liquids, solids, gases, elasticity, etc., with interesting practical applications.

FORCES. Some articles: *Top Dead Centre, Setting a Flight Course, High Wire Circus Artistes.* The course covers combination of forces, stability, levers, pulleys, gears and the inclined plane.

FRICTION, POWER, MASS. Short courses on each of these are also included, with such titles as *Disc Brakes.*

the Electrical & Nuclear Physics group

Electricity and electronics are powerful factors in the life of every advanced country today—this is in fact the electronic age. Yet even electricity is a mystery to most people and is rightly regarded as one of the most difficult subjects to learn because nearly everything depends upon mathematical ideas. UNDERSTANDING SCIENCE presents outlines of these subjects that are lucid and constructively informative, but do not use mathematics as the basis of explanations—by careful presentation and a special type of picture the basic principles (even of radio circuits and computers) are turned into interesting articles that the unspecialised reader can grasp. Students will find these a wonderful help to memorising all the fundamental principles.

AN OUTLINE OF MAGNETISM. Some articles: *One Magnet Makes Another, Magnetic Workhorses—Solenoids, The Sun is a Magnet.* Bar magnets and their behaviour are a fascinating study; this is followed by electromagnets, compasses, terrestrial magnetism.

AN OUTLINE OF ELECTRICITY. UNDERSTANDING SCIENCE makes an early start with this important subject. The electron flow theory is very lucidly given and these articles and those that follow in further issues are completely suitable even for those who have had no previous introduction. Typical articles: *The Making of Electricity, Taking a Furnace's Temperature, The Photographer's Lightmeter, The Third Pin, Why Most Countries Have an Electric Grid, Paying for Electricity.*

AN OUTLINE OF STATIC ELECTRICITY. For simplicity this side of the study of electricity has a separate series of articles. They run from friction machines through lightning and condensers to switchgear and the crystal in a record player pick-up.

AN OUTLINE OF ELECTRONICS. A very full coverage of radio, television and radar principles is given, with separate and vivid explanations of each stage of typical circuits, also transistors, aerials, microphones and loudspeakers; a number of articles are devoted to each. Later on the electron microscope, computers, the photo-electric cell, geiger counters, photomultipliers and other electronic devices are very fully explained. Some articles: *The Electron Cloud, An Electric Gate, Direction Finding Aerials, Circular Time Bases, Ground Control Approach, Seeing the Unseeable, Programming a Digital Computer, Compatibility—the Colour TV Dilemma.*

NUCLEAR PHYSICS

AN OUTLINE OF NUCLEAR PHYSICS. The discoveries and development work that have transformed our world began in 1896 when Henri Becquerel accidentally left a sealed packet of unexposed photographic plates under a piece of uranium ore. He later found the plates were 'fogged', though no light could have reached them. He concluded that uranium gives out rays that pass through paper and even metal—radio-activity. Since then the pace has been tremendous. Charles Wilson's cloud chamber (1913) allowed photos of 'jet trails' of nuclear particles to be taken. In 1932 Sir John Cockcroft transmuted one element into another, in 1934 Sir James Chadwick discovered the neutron, trigger of chain reactions. Enrico Fermi built the first atomic pile in 1942. Now we live at the dawn of the age of nuclear power. This fascinating series of articles explains what is involved in such things as cyclotrons, isotopes, breeder reactors, the reasons for the deadliness of radio-activity to living things, nuclear fusion, anti-matter.

the Natural Sciences group

To study the natural world requires a number of extraordinarily interesting sciences. Articles from among the various outlines of these will be included in many issues of UNDERSTANDING SCIENCE. Spotlighting as they do some of the most absorbing scientific work, they will be wonderfully entertaining as well as informative.

GEOLOGY. Structure, materials and history of the earth's crust; terms, techniques.
MINERALOGY. Metallic and non-metallic ores, crystals, methods.
PALAEOGEOGRAPHY. Detailed survey of the ancient geography of each continent, dating techniques.
NAVIGATION. The basic principles of finding positions.
METEOROLOGY. The causes of weather, forecasting.
GEOMORPHOLOGY. The changes in the face of the land.
CLIMATOLOGY. Classification and causes.
CARTOGRAPHY. Map projections, and map making.
ASTRONOMY. The apparent movement of stars and planets in the sky, astronomers' work, theories of the nature of the universe.
ASTROPHYSICS. The lives of the stars and the theories about them.
GEOPHYSICS. The formation and future of the Earth and the critical balance of factors that allow life on it.

binders

So that readers may easily keep together all the parts of UNDERSTANDING SCIENCE and build it into the complete and valuable study-aid encyclopaedia that it is designed to form, special binders to hold UNDERSTANDING SCIENCE are available and readers who require them will be able to purchase them from their usual newsagent. A special announcement concerning an *INTRODUCTORY OFFER* will be contained in the early issues of UNDERSTANDING SCIENCE.

index

A complete index for each volume will be made available for insertion in the binder.

HEAVISIDE, OLIVER (1850–1925) Britain, physicist. Predicted the existence of the layer of gases (Heaviside layer) in the ionosphere which are able to reflect radio waves back to Earth.

HEISENBERG, WERNER KARL (1901–) Germany, physicist. Noted for his work on atomic structure, he founded quantum mechanics. Also formulated the uncertainty principle.

HERSCHEL, SIR FREDERICK WILLIAM (1738–1822) b. Germany, astronomer. Devised a new kind of reflecting telescope. Discovered Uranus and two of its satellites.

HERTZ, HEINRICH (1857–1894) Germany, physicist. He proved experimentally the existence of radio waves and showed their similarity to light radiation.

HOOKE, ROBERT (1635–1703) Britain, physicist. Worked on mathematics, air pressure and magnetism and studied the microscope and the telescope.

HOOKER, SIR JOSEPH DALTON (1817–1911) Britain, botanist. Noted for his book *Genera Plantarium* which he wrote with Bentham. This contained a new and important system of plant classification.

HOPKINS, SIR FREDERICK GOWLAND (1861–1947) Britain, biochemist. His researches on proteins and vitamins were of great importance. His work led to the discovery of essential amino acids.

HUMBOLDT, BARON FRIEDRICH VON (1769–1859) Germany, geographer. Explored South America and Central Asia making many observations on natural phenomena.

HUNTER, JOHN (1728–1793) Britain, surgeon and anatomist. The leading surgeon of his day, Hunter founded scientific surgery, introducing many surgical techniques.

HUTTON, JAMES (1726–1797) Britain, geologist. Put forward the idea that the stratified layers of rocks on Earth are the result of processes which are still going on.

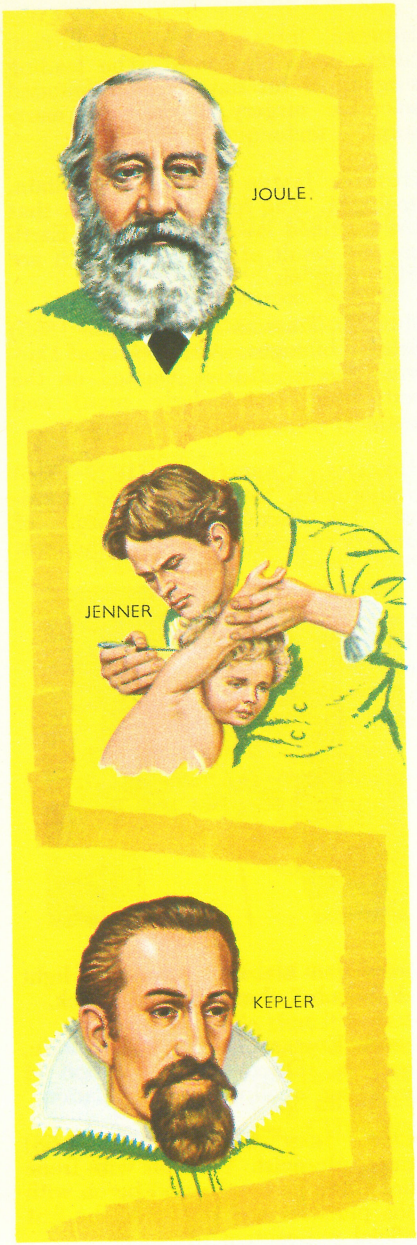
HUXLEY, THOMAS HENRY (1825–1895) Britain, biologist. A supporter of Darwin's theory, Huxley worked on the vertebrates (particularly man) and methods of teaching science.

HUYGENS, CHRISTIAAN (1629–1695) Netherlands, astronomer and physicist. He discovered the nature of Saturn's rings and one of its satellites.

Formulated his wave theory of light and invented the pendulum clock.

JENNER, EDWARD (1749–1823) Britain, physician. Discovered a method of preventing smallpox by inoculation.

JOLIOT, JEAN FRÉDÉRIC (1900–58) France, physicist. With his wife Irene Joliot Curie he bombarded boron with alpha particles and produced the first artificial radioactive substance.



JOULE, JAMES PRESCOTT (1818–1889) Britain, physicist. Famous for his determination of the mechanical equivalent of heat and his researches into electricity and magnetism. The unit of energy is named after him.

KEKULÉ, FRIEDRICH AUGUST (1829–1896) Germany, chemist. His discovery of the ring-like arrangement of carbon atoms in benzene was a milestone in organic chemistry.

KELVIN, LORD WILLIAM THOMSON (1824–1907) Britain, mathematician and physicist. Invented the mirror galvanometer, Kelvin balance and quadrant electrometer. He introduced the Kelvin absolute temperature scale.

KEPLER, JOHANNES (1571–1630) Germany, astronomer. His three laws of motion are of great importance to astronomy and provide the basis of Newton's research in gravity.

KOCH, ROBERT (1843–1910) Germany, bacteriologist. Discovered the organisms which cause anthrax, tuberculosis and cholera. Also developed new staining techniques and new methods of culturing bacteria.

LAMARCK, JEAN BAPTISTE (1744–1829) France, naturalist. Famous mainly for his theory of evolution (Lamarckism) in which the inheritance of acquired characteristics was held to explain the origin of species.

LAPLACE, PIERRE SIMON, MARQUIS DE (1749–1827) France, mathematician. Solved many of the mathematical problems of the solar system. Derived the law governing the magnetic field around a current.

LAVOISIER, ANTOINE LAURENT (1743–1794) France, chemist. He discovered the nature of combustion and finally disproved the phlogiston theory. He also discovered that animals need oxygen to live.

LEEUWENHOEK, ANTON VAN (1632–1723) Netherlands, microscopist. With his simple lenses he made many important discoveries, and made observations of microbes, of blood corpuscles and animal tissues.

LIEBIG, JUSTUS, BARON VON (1803–1873) Germany, chemist. Best known for his invention of the Liebig condenser. He is important for his work in agriculture, plant nutrition and organic chemistry.

LINNAEUS, CAROLUS (1707–1778) Sweden, botanist. He is well known for his work on plant and animal classification. He wrote *Systema Naturae*.

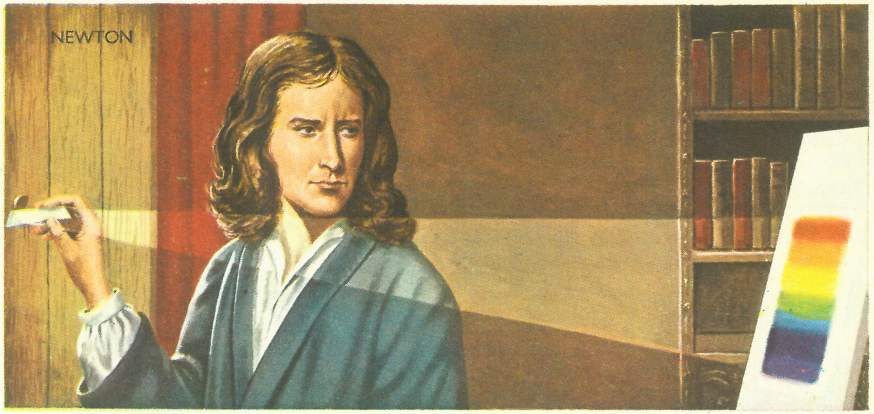
LISTER, BARON JOSEPH (1827–1912) Britain, surgeon. He introduced antiseptics into medical science and later aseptic surgery.

LOVELL, SIR ALFRED CHARLES BERNARD (1913–) Britain, astronomer. Professor of astronomy at Manchester University, worked on various problems, especially the exploration of space by radio.

LOWELL, PERCIVAL (1855–1916) U.S.A., astronomer. Famous for his predictions which led to the discovery of Pluto, the outermost of the planets.

LYELL, SIR CHARLES (1797–1875) Britain, geologist. The author of many geological works, Lyell supported the theory that past changes in the Earth's crust were due to the same causes as changes now taking place.

MALPIGHI, MARCELLO (1628–1694) Italy, physician and anatomist. He discovered the capillaries between arteries and veins and studied animal and plant embryology, plant anatomy and animal histology.



MANSON, SIR PATRICK (1844–1922) Britain, physician. Famous for his research into tropical medicine, he was the first to show that insects carried some of the disease-causing organisms.

MAXWELL, JAMES CLERK (1831–1879) Britain, physicist. Famous for the mathematical research that led to the discovery of radio.

MELVILLE, SIR HARRY WORK (1908–) Britain, chemist. While professor of chemistry at Aberdeen and Birmingham Universities did world-renowned work on the chemistry of polymers. He published a famous work about "big molecules".

MENDEL, GREGOR JOHANN (1822–1884) Austria, naturalist. Famous for his work on heredity, pioneered the study of the fundamental laws of inheritance. His work forms the basis of Mendelism.

MENDELÉEF, DMITRI IVANOVICH (1834–1907) Russia, chemist. He is famous for his formulation of the periodic law based on atomic weights.

MERCATOR, GERARDUS (1512–1594) Belgium, geographer. The best known early globe and mapmaker. The projection named after him is still used today.

MICHELSON, ALBERT ABRAHAM (1852–1931) U.S.A., physicist. He determined the speed of light and made practical studies on ether drift. He also invented an interferometer for the study of spectral lines.

MILLIKAN, ROBERT ANDREWS (1868–1953) U.S.A., physicist. He determined the value of the charge on the electron by a famous experiment using oil drops.

NEWTON, SIR ISAAC (1642–1727) Britain, mathematician. Noted for his work on gravity. Discovered the three basic laws of motion, and the relationship between colour and light. His work on optics, mathematical problems and astronomy has been of immense importance.

OERSTED, HANS CHRISTIAN (1777–1851) Denmark, physicist. A pioneer of research into electro-magnetism, Oersted discovered the basic principle that a wire carrying a current is surrounded by a magnetic field.

OHM, GEORG SIMON (1787–1854) Germany, physicist. The unit of electrical resistance is named after him and his law is of fundamental importance in electricity.

PARACELSUS, PHILIPPUS (1493–1541) Switzerland, alchemist. Emphasised the links between chemistry and medicine. Reputed to have developed cures for many ailments.

PASCAL, BLAISE (1623–1662) France, mathematician and physicist. Carried out experiments on pressure in liquids and to show that atmospheric pressure decreases with height. Helped to develop the theory of probability.

PASTEUR, LOUIS (1822–1895) France, bacteriologist. His experiments on fermentation destroyed the myth of spontaneous generation. He founded the science of bacteriology and discovered artificial immunity.

PAVLOV, IVAN PETROVICH (1849–1936) Russia, pathologist. He is noted for his work on the physiology of digestion and on conditioned reflexes.

PERKIN, SIR WILLIAM HENRY (1838–1907) Britain, chemist. Discovered the first aniline dye, mauve. Later he went on to manufacture dyes commercially. His son, who had the same name (1860–1929), was also a well-known chemist.

PICCARD, AUGUSTE (1884–1962) Switzerland, physicist. Explored atmosphere in a balloon and the ocean depths in a bathysphere of his own design.

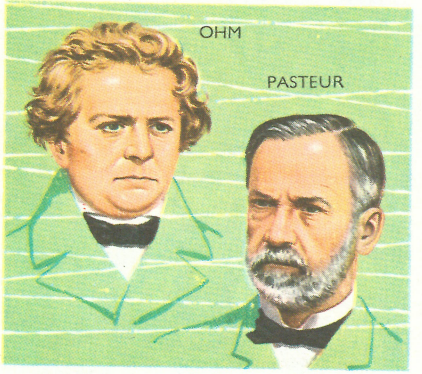
PLANCK, MAX KARL ERNST LUDWIG (1858–1947) Germany, physicist. Evolved the Quantum Theory, and also worked on thermodynamics and optics.

PRIESTLEY, JOSEPH (1733–1804) Britain, chemist. Priestley discovered oxygen but failed to realise its true role in combustion and termed it 'dephlogistated air'. Also discovered ammonia and the oxides of nitrogen, carbon monoxide and sulphur dioxide.

RAMON Y CAJAL (1852–1934) Spain, histologist. His work on the nervous system is outstanding. He made important discoveries about the structure and form of nerve cells, especially in the brain and spinal cord.

RAY, JOHN (1627–1705) Britain, naturalist. Greatest early British naturalist, he was principally a botanist, stressing the difference between monocotyledons and dicotyledons. Also interested in the study of insects.

ROEMER, OLAUS (1644–1710) Denmark, astronomer. Produced the first reliable estimate of the speed of light, calculated by observing eclipses of Jupiter's satellites.



RÖNTGEN, WILHELM KONRAD (1845–1923) Germany, physicist. His discovery of X-rays revolutionized certain aspects of physics and medicine.

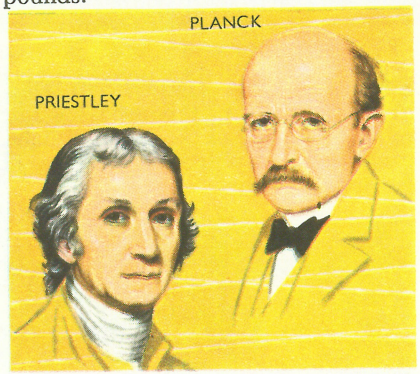
ROSS, SIR RONALD (1857–1932) Britain, physician. He proved that the female *Anopheles* mosquito carries the parasite which causes malaria and transmits it to man by its bite.

t part plunger and turns with it. Because the stem is rather divisions are sub-divided

RUMFORD, COUNT (1753–1814) b. U.S.A., physicist. Showed that heat is a form of energy.

RUTHERFORD, LORD ERNEST (1871–1937) Britain, physicist. The discoverer of alpha, beta and gamma rays emitted by radioactive substances. Famous for his theory on the structure of the atom, he was the first to cause the transmutation of an element.

SCHEELE, KARL WILHELM (1742–1786) Sweden, chemist. He discovered oxygen, chlorine and glycerine and synthesised a number of organic compounds.



SCHLEIDEN, MATTHIAS JACOB (1804–1881) Germany, botanist. With Schwann he developed the 'cell theory'.

SCHRODINGER, ERWIN (1887–) Austria, physicist. Especially noted for his work on wave mechanics.

SCHWANN, THEODOR (1810–1882) Germany, anatomist. With Schleiden he developed the 'cell theory' working on animal tissue. He discovered the enzyme pepsin.

SIMPSON, SIR JAMES YOUNG (1811–1870) Britain, physician. Famous for his discovery of the anaesthetic properties of chloroform; the first to use anaesthetics in surgery.

SMITH, WILLIAM (1769–1839) Britain, geologist. He showed that rocks could be dated by noting the fossils contained in them.

SODDY, FREDERICK (1877–1956) Britain, physicist and chemist. Famous for his discovery of isotopes and subsequent work on them. With Rutherford put forward the theory of spontaneous disintegration.

STOKES, SIR GEORGE GABRIEL (1819–1903) Britain, mathematician and physicist. Discovered how to determine the chemical composition of the Sun and stars from their spectra. Also formulated Stokes' law of viscosity.

THALES (*c.* 640–546 B.C.) Greece, mathematician. First scientist to predict an eclipse of the Sun. An early exponent of geometry.

THOMSON, SIR GEORGE PAGET (1892–) Britain, physicist. Discovered the diffraction of electrons by crystals. Son of Sir J. J. Thomson.

THOMSON, SIR J. J. (1856–1940) Britain, physicist. Famous for his determination of $\frac{e}{m}$ (charge of electron ÷ its mass), and his discovery that cathode rays consist of electrons which are negatively charged particles.

TOMBAUGH, CLYDE WILLIAM (1906–) U.S.A. astronomer. Famous as the discoverer of the planet Pluto, working on Lowell's predictions.

TORRICELLI, EVANGELISTA (1608–1647) Italy, physicist. He invented the mercury barometer and built a simple microscope.

UREY, HAROLD CLAYTON (1893–) U.S.A., chemist. He was the first to isolate heavy water and thus to discover deuterium. He is an authority on isotopes.

VAN'T HOFF, JACOBUS HENRICUS (1852–1911) Netherlands, physicist. His name is associated with a law relating to the balance of chemical reactions. Also noted for his researches on osmotic pressure.

VESALIUS, ANDREAS (1514–1564) Belgium, anatomist. Regarded as the father of modern anatomy, he made many discoveries by painstaking dissections. Much of his work is contained in his book *De Humani Corporis Fabrica.*

VIRCHOW, RUDOLF (1821–1902) Germany, pathologist. Conducted important research into diseased body cells.

VOLTA, COUNT ALESSANDRO (1745–1827) Italy, physicist. He developed the theory of current electricity and invented the first electric battery. The unit of electrical pressure known as the volt is named after him.

WALLACE, ALFRED RUSSEL (1823–1913) Britain, naturalist. With Darwin he published a paper on the theory of evolution. Wallace's line, an imaginary line, separates the areas of Asiatic and Australian fauna.

WATSON-WATT, SIR ROBERT (1892–) Britain, physicist. A pioneer of radar, the radio location system so important during and since the Second World War.

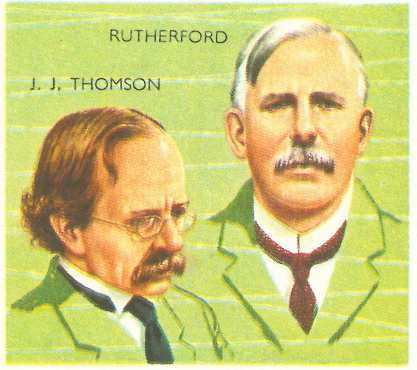
WEBER, WILHELM EDUARD (1804–1891) Germany, physicist. Studied a wide field of physical problems, especially electricity, heat and the magnetism of the Earth.

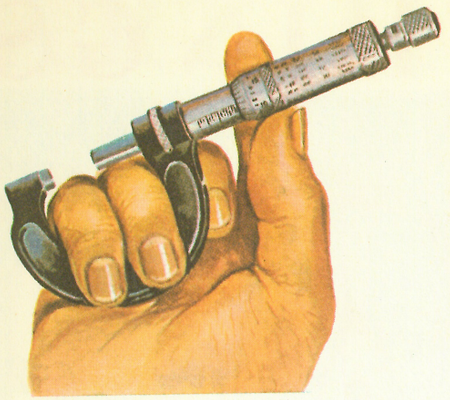
WEGENER, ALFRED LOTHAR (1880–1930) Germany, geologist. Famous for his hypothesis regarding continental drift.

WHEATSTONE, SIR CHARLES (1802–1875) Britain, physicist. An experimenter in sound and a prolific inventor, he is best known now for the 'Wheatstone bridge', a device for comparing electrical resistances.

WILSON, CHARLES THOMSON REES (1869–1959) Britain, physicist. Famous for his invention of the cloud chamber which has proved invaluable in atomic studies.

YOUNG, JOHN ZACHARY (1907–) Britain, physiologist. Noted for his work in the field of nervous physiology, and particularly for his famous experiments with the giant nerve fibres of squids.

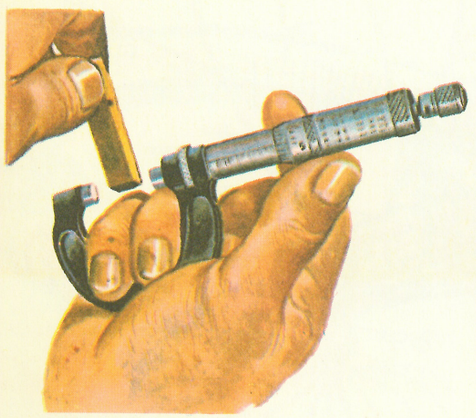




1.

The micrometer is held in the right hand so that the scale is clearly visible to the operator.

The first step before using a micrometer is to check the zero reading. To do this it is necessary to close the mouth of the instrument by turning the friction knob only. When the friction knob begins to slip round both the fixed and moving scales should read 'o'. Whatever reading is obtained with the mouth of the instrument closed must be *subtracted* from all subsequent readings.



2.

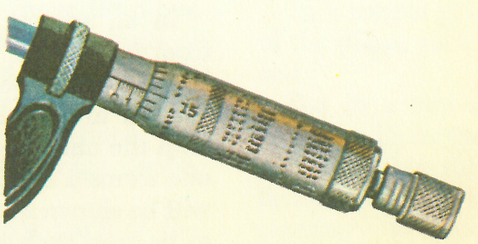
The next step is to rotate the stem anti-clockwise between thumb and forefinger, holding the instrument as shown, until the mouth of the instrument is wide enough to fit over the specimen. It will probably be found more comfortable to use the roughened ring near the moving scale instead of the main thumb grip at the end of the stem. With the specimen in place the stem is turned gently clockwise to close the mouth of the micrometer.

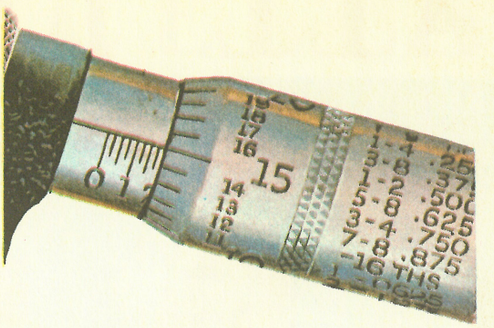
3.

Just before the specimen becomes clamped between the anvil and the plunger the thumb and forefinger are transferred to the friction knob and the final rotation done from there. This ensures firstly that the important screw thread is not put under any strain and secondly that the specimen is not squeezed so tightly as to alter its thickness. Care should be taken to see that the specimen is seated squarely between the anvil and the plunger; if it is at all skewed it can lead to very serious errors.

4.

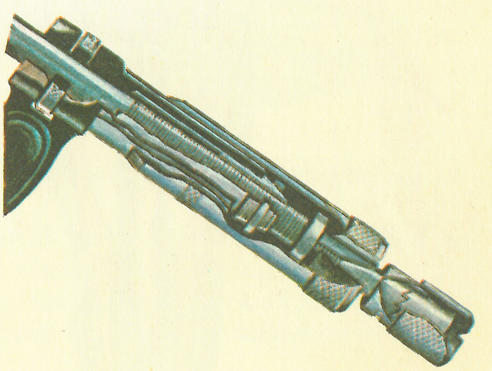
The micrometer used here is graduated in inches and each numbered division on the fixed scale represents one-tenth (0·1) of an inch. These divisions are sub-divided into four so that each small division represents one-fortieth (0·025) of an inch. The moving scale is graduated from 0 to 25 and one fixed scale small division is uncovered by turning the stem through one revolution. Hence 25 moving scale divisions represent 0·025 ($\frac{1}{40}$) inches or 1 moving scale division represents 0·001 ($\frac{1}{1000}$) inches.





5.

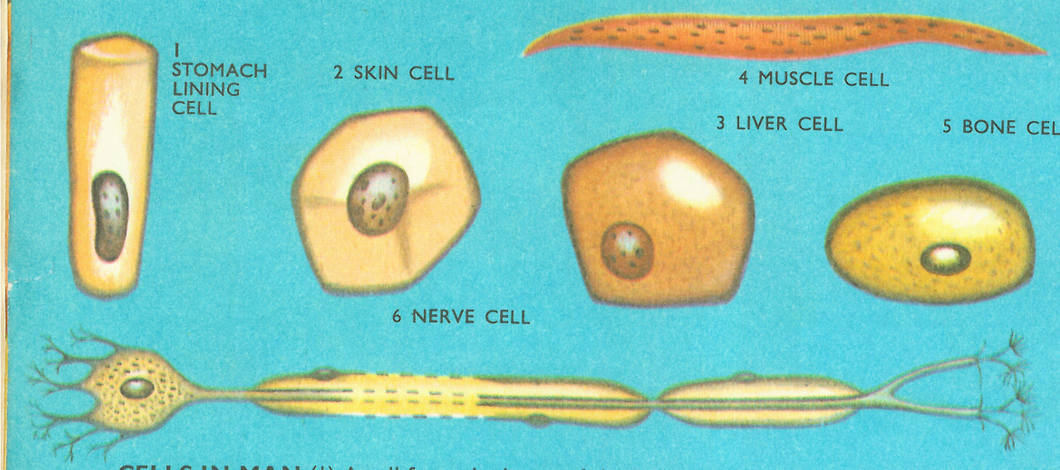
To read the micrometer we first note the number of large (0·1 inch) divisions that are completely uncovered on the barrel. Next we count the quarters of the division which is only partly uncovered. Each of these represents 0·025 inch. Finally we read the number on the moving scale nearest to the line engraved on the barrel. This gives the number of moving scale divisions, each of which represents 0·001 inches. Then the three readings are added. In this example a fixed scale reading of 1 large division, 3 small (quarter) divisions and a moving scale reading of 15 divisions adds up to 0·1 in. + 0·075 in. + 0·015 in. giving a total of 0·190 inches. On the facing page we see a micrometer showing 3 large divisions, 2 small (quarter) divisions and 7 moving scale divisions. The thickness of that specimen is read as 0·3 + 0·05 + 0·007 giving a total of 0·357 inches.



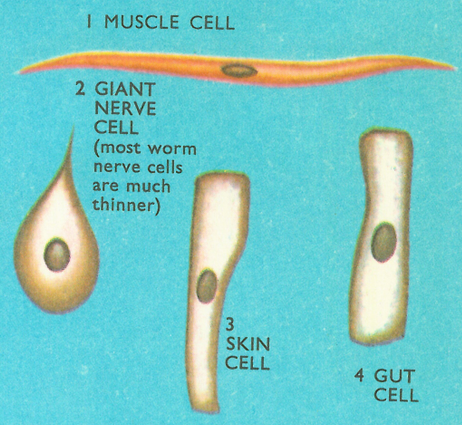
6.

A cutaway to show the screw thread on the concealed end of the plunger. This turns in the matching screw thread inside the barrel.

ALL LIVING THINGS

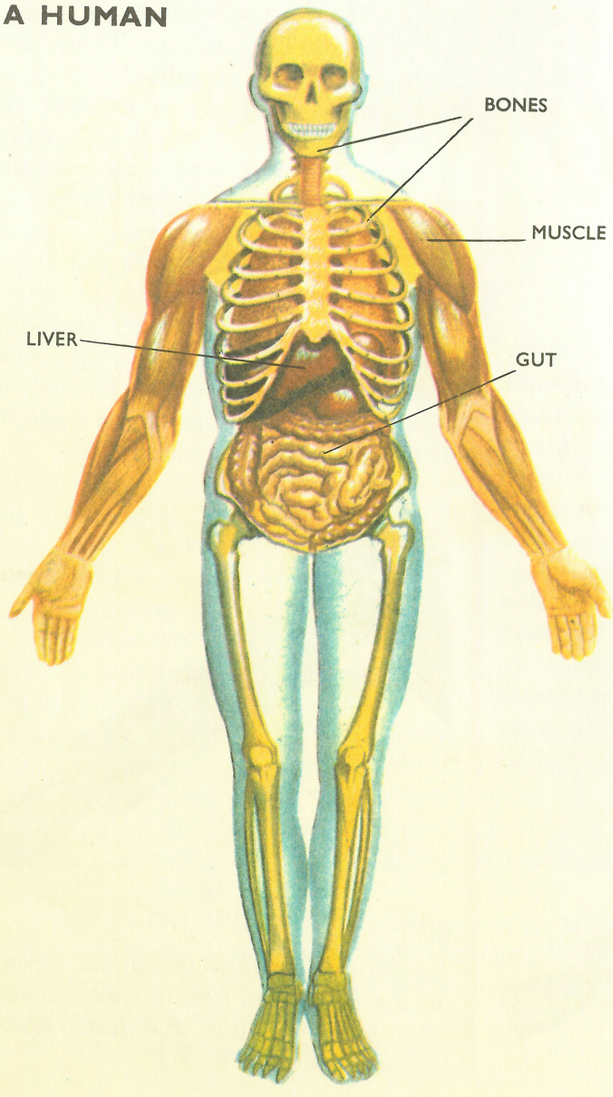


CELLS IN MAN (1) A cell from the lining of the stomach ($\frac{1}{900}$ inch). (2) A cell from an inner layer of skin ($\frac{1}{2000}$ inch). (3) A liver cell ($\frac{1}{1000}$ inch). (4) A muscle cell which may be between 2 inches and 20 inches long and $\frac{1}{250}$ to $\frac{1}{2500}$ inch in diameter. (5) A bone cell ($\frac{1}{1250}$ inch). (6) A nerve cell which may be 3 feet long but less than $\frac{1}{1000}$ inch in diameter.

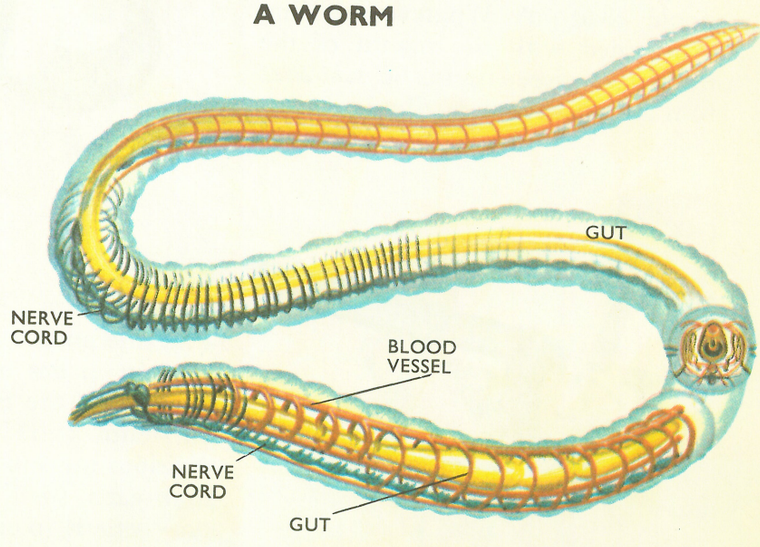


CELLS IN A WORM (1) A muscle cell ($\frac{1}{25}$ inch). (2) A giant nerve cell from the nerve cord ($\frac{1}{250}$ inch). (3) A skin cell ($\frac{1}{200}$ inch). (4) A gut cell ($\frac{1}{250}$ inch).

A HUMAN



A WORM

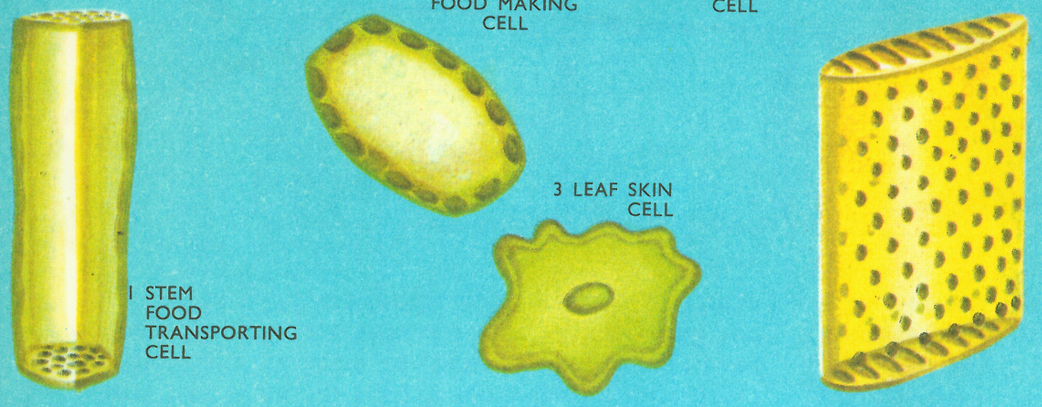


JUST as a house is made of bricks so animals and plants are made up of tiny units called cells. But there are many different kinds of cells. Each cell in each part of the body has a special design so that it can perform a certain task.

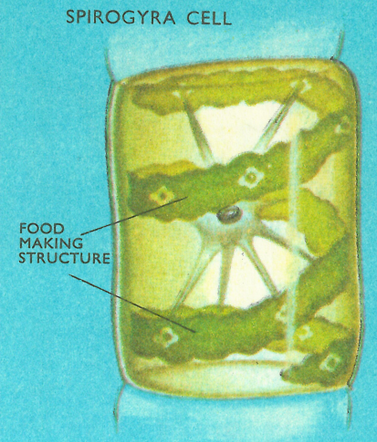
In an animal a muscle cell differs in size and shape from a skin cell, in a plant a leaf cell differs in size and shape from a root cell.

Cells are small, too small, generally speaking, to see with the naked eye. There are some cells of which a single one forms a complete animal or a complete plant. These will be shown in later articles, most of them are too small to be seen with the naked eye though a few are as large as $\frac{1}{2}$ inch across.

ARE MADE OF CELLS

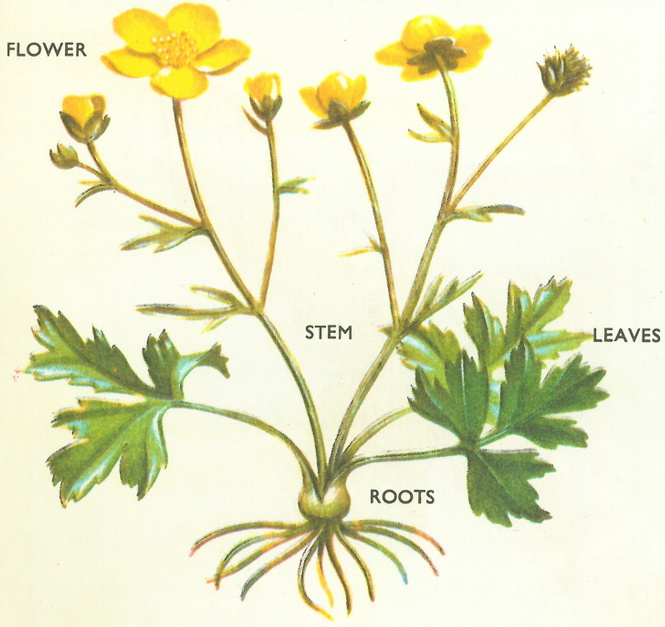


CELLS IN A FLOWERING PLANT (1) A stem cell through which food passes from one part of the plant to another. (2) A leaf cell in which food is made in the round bodies called chloroplasts. (3) A cell which forms part of the outer skin or epidermis of the leaf. (4) A stem cell which passes water to the leaves.

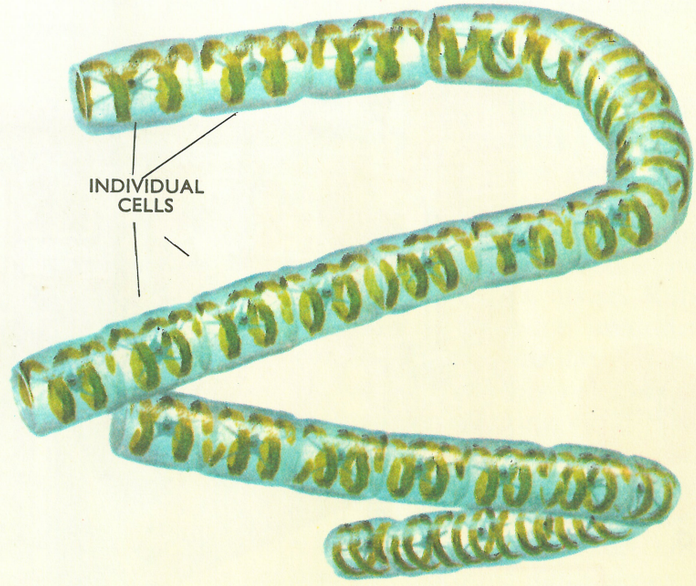


CELL OF SIMPLE PLANT A single cell of Spirogyra (part of the green scum on ponds), a plant which is merely a chain of similar cells.

A FLOWERING PLANT



A SIMPLE GREEN PLANT—SPIROGYRA



The illustrations at the top of page 10 show six of the many kinds of cells of which we are built.

Practically all animals have muscle cells, but no plants have them. They are long, thin cells which, by shortening and lengthening, enable us to move from one place to another. We also have bone cells, thousands of which grow together and form our bones. A worm does not have a hard skeleton, and therefore has no bone cells.

Gut cells are specially equipped to produce the chemicals that digest food. Liver cells are storage depôts for sugar that the body needs.

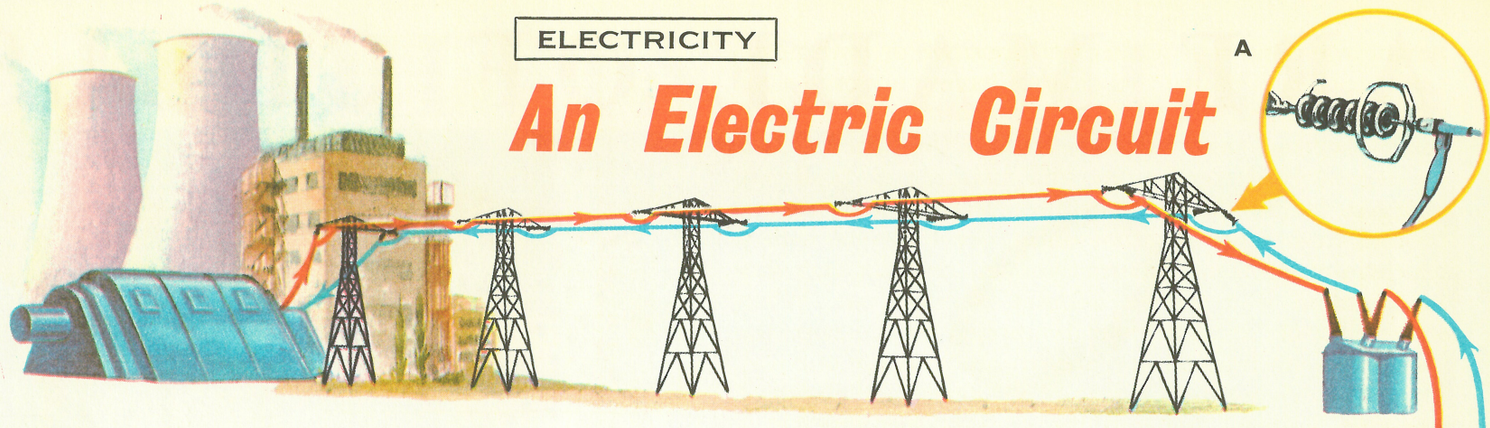
Nerve cells pass signals between different parts of the body, releasing, it is thought, chemicals at the nerve endings that cause responses, such as the shortening of a muscle.

The large, dark oval body in each cell is called a nucleus. The nucleus controls the working of a cell.

In a simple green plant like Spirogyra all the activities of the plant, such as food-making, are carried on in every cell.

But in a flowering plant food-making is restricted to special cells in the leaves, the roots serve to take in water and to anchor the plant to the ground, and the cells in the flowers produce the pollen grains and ovules which are necessary to produce the seeds from which the young plants will grow.

An Electric Circuit

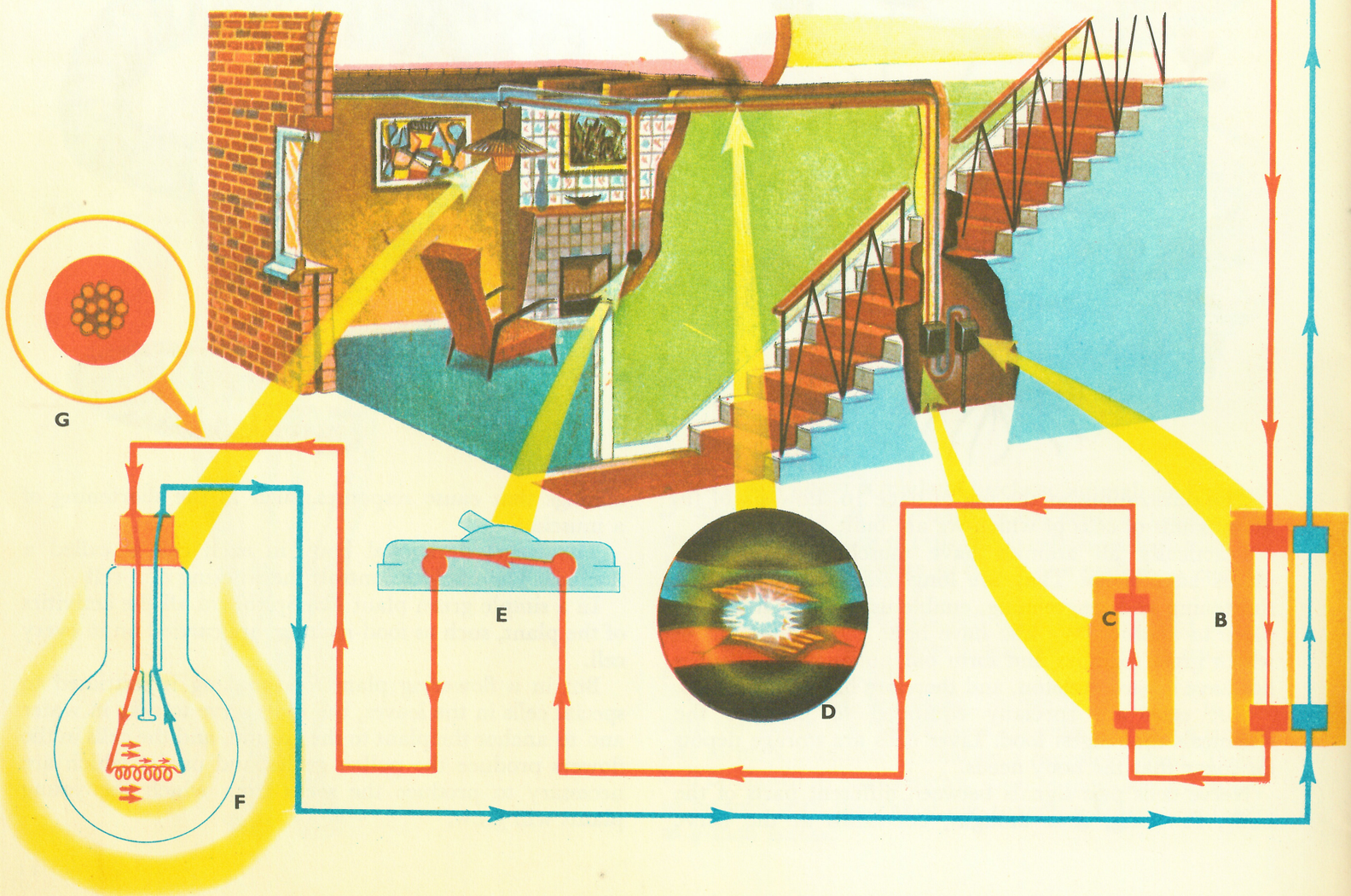


OF ALL FORMS of energy, electricity is the most baffling and difficult to describe. A current cannot be seen. In fact it does not exist outside the wires and so on which carry it. A 'live' wire carrying a current looks exactly the same and weighs exactly the same as it does when it is not carrying a current.

An electric *current* is simply a movement or *flow* of electricity. The electricity is carried by minute particles called electrons. Electrons are very much smaller than atoms—in fact the outermost part of every atom consists of a number of electrons whirling around a central core or nucleus. Each electron has the same charge or 'packet' of electricity described as a *negative* charge. Usually the nucleus has exactly enough *positive* electrical charges to balance the negative charges on the electrons so that the atom as a whole is neutral.

A few of the electrons in each atom of a conductor such as copper are only loosely held. These 'free electrons' can jump from atom to atom and it is a steady drift of free electrons that carries electricity through a wire.

Why should electrons move about between atoms? The basic law of electricity says that two charges

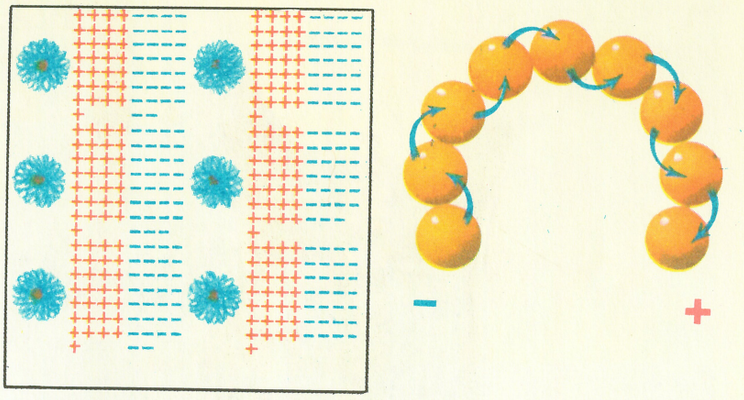


having the same sign (either both positive or both negative) repel each other; two charges having opposite signs (one positive and the other negative) attract each other. Since electrons carry negative charges they are repelled by negatively charged atoms and attracted by positively charged atoms. As a result the electrons are pushed around from atom to atom until they find one with a shortage of electrons. Alternatively an electron may stay in an atom if it pushes another electron out. When some kind of 'driving force' is applied to the wire the wandering electrons are organised into a steady one-way drift. The driving force is simply a difference of electrical pressure (voltage) between the ends of the wire. It is provided by either a battery or generator (dynamo). Electrical pressure starts the drift of electrons by pushing the loosely held electrons from the first atom in the line to the next atom and so on.

Two points that must be borne in mind regarding the flow of electricity along a wire are, first, that the electrons which set out from one end are not the same electrons that reach the other end. Secondly, that by convention a current is said to flow through a circuit from the positive terminal of a battery to the negative terminal. In fact the moving electrons flow in the opposite direction. This confusing state of affairs dates back to early studies in electricity and cannot easily be put right now.

A current of electricity must have a completely unbroken path or circuit. If we could follow a current as it flowed along a wire we should eventually arrive back at our starting point. Wires which lead the current from one part of the circuit to another are nearly always made of copper. Copper, like most metals, is a good *conductor* of electricity; it has plenty of free electrons so a current has little difficulty in travelling through copper. Actually the best conductor is silver, but this metal would be far too expensive for wiring a house. Rubber and plastics are good insulators (or, what amounts to the same thing, bad conductors). An insulator is made up of atoms that do *not* have any loosely held electrons and these materials are used for covering electric wires so that if the outgoing and returning parts of the wires touch there will not be any short cut for the current that reduces the planned length of the circuit (*i.e.*, a 'short circuit'). There is a danger that a short circuit will cause sparks because the electrons jump across any *tiny* air gap between bare wires. This sparking can cause a fire if the wires rest against wood or anything else that is inflammable.

Looking at the diagram on the left we can trace a typical circuit around which current flows from a generator in the power station to and through a lamp in the home and back again to its starting point. The current starts out along cables supported on pylons. These cables are not insulated with rubber or plastic—they do not have to be because the large amount of air which surrounds them is an excellent insulator. Of course they are insulated from the pylon by glass blocks like that shown in the diagram, otherwise the electrons would shortcut through the pylon to the Earth. The current passes into



An atom is neutral (uncharged) when the number of positively charged particles (protons) in its nucleus is equal to the number of negatively charged particles (electrons) outside the nucleus. If the atom as a whole gains extra electrons it becomes negatively charged, if it loses electrons it becomes positively charged.

A copper atom always has 29 protons (+). The copper atoms on the left are all negatively charged because they have more than 29 electrons (—). The copper atoms on the right are all positively charged because they have less than 29 electrons (—).

Electrons are repelled by negative atoms and attracted to positive atoms. That is why electrons flow along a wire, passing from atom to atom as shown in the diagram. But it is not always the incoming electron itself that passes on to the next atom, it may instead push out one of the loosely bound electrons already present.

The picture on the left shows, in a very much simplified manner, the circuit of an electric lamp. The wires in the house form only a small part of the complete circuit, for the wires which bring the current from the power station many miles away are also part of the same circuit.

Inset A shows one of the massive glass insulators that prevent the current passing into the pylons supporting the cables. The ridges are to throw off rain water that could otherwise form a conducting path over the insulator.

Inset B shows the main fuses, one each in the supply wire and in the return wire. They are usually thin wires made of some metal that melts easily when it is heated.

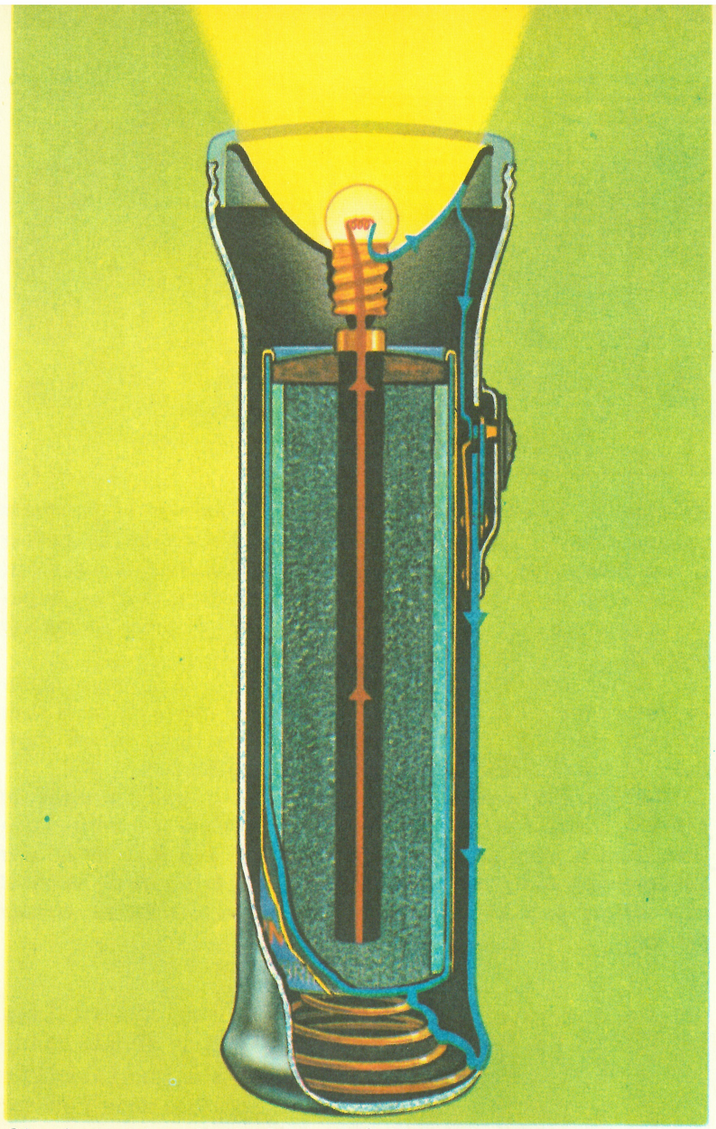
Inset C shows one of the smaller fuses that protects each of the subsidiary circuits branching off from the main fuse box. The fuse wires which are mounted on blocks of porcelain (a good insulator), are thick enough to carry a certain amount of current without getting hot. But an excessive current causes them to overheat, melt and break the circuit.

Inset D shows a 'short circuit' caused by the insulation of two adjacent wires being damaged. Current passes directly from the supply wire to the return wire because this path is shorter than having to flow around the rest of the circuit. Sparks and a great deal of heat are produced as the current leaps across the slight gap between the wires.

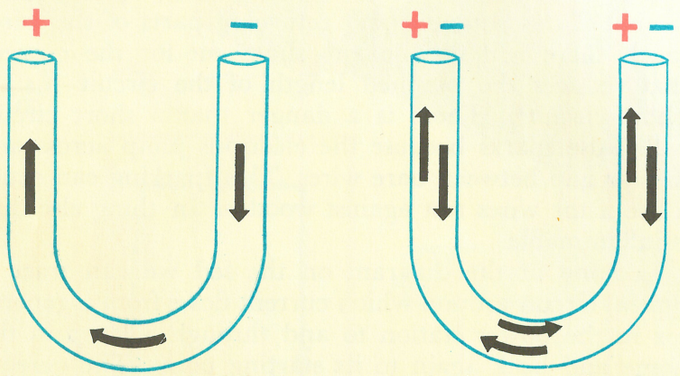
Inset E shows a switch that can be opened to break the circuit and so stop the flow of current to the lamp.

Inset F shows an electric light bulb containing a coil of tungsten wire so fine that it is made white hot by the current passing through it. The bulb is usually filled with argon, a gas that does not combine with tungsten.

Inset G shows a cross section through one of the wires used in this circuit. It is made up of several strands of copper twisted together, making it much more flexible than a single copper wire of the same diameter. Copper is a very good conductor of electricity; the rubber or plastic which covers the wire is a very good insulator.



Chemical actions in the battery of this torch put a positive charge onto its central carbon rod and a negative charge onto its zinc shell. Electrons flow from the zinc through the metal of the torch and back by way of the bulb to the carbon rod. But the convention is to pretend that electric current flows from plus to minus, not in the direction the electrons really flow—from negative to positive. The arrows show the 'conventional' direction.



The diagram on the left shows a wire having a positive charge at one end and a negative charge at the other. The electrons flow in the same direction all the time. This is a **direct current** *(D.C.).*

The diagram on the right shows a wire where the charges at the ends are periodically switched round causing electrons to flow first one way and then the other. This to-and-from movement of electrons is an **alternating current** *(A.C.).*

insulated underground cables or overhead wires that bring it to the house.

As soon as it enters the house the current passes through the main fuses, then the circuit divides to lead the current to all the different lamps and power points. Each of the subsidiary circuits should have its own fuse. ('Inset C,' p. 12.) A fuse is a thin piece of wire made from a low-melting-point metal. When the current is more than the wiring can safely carry the fuse gets hot, because it is not such a good conductor as the rest of the circuit, and melts. So the circuit is broken and the current stops. In the diagram (p. 12) the subsidiary circuit leads current from the fuse box, by way of a switch, to a light bulb. If the switch were open no flow of electricity could take place in that particular circuit.

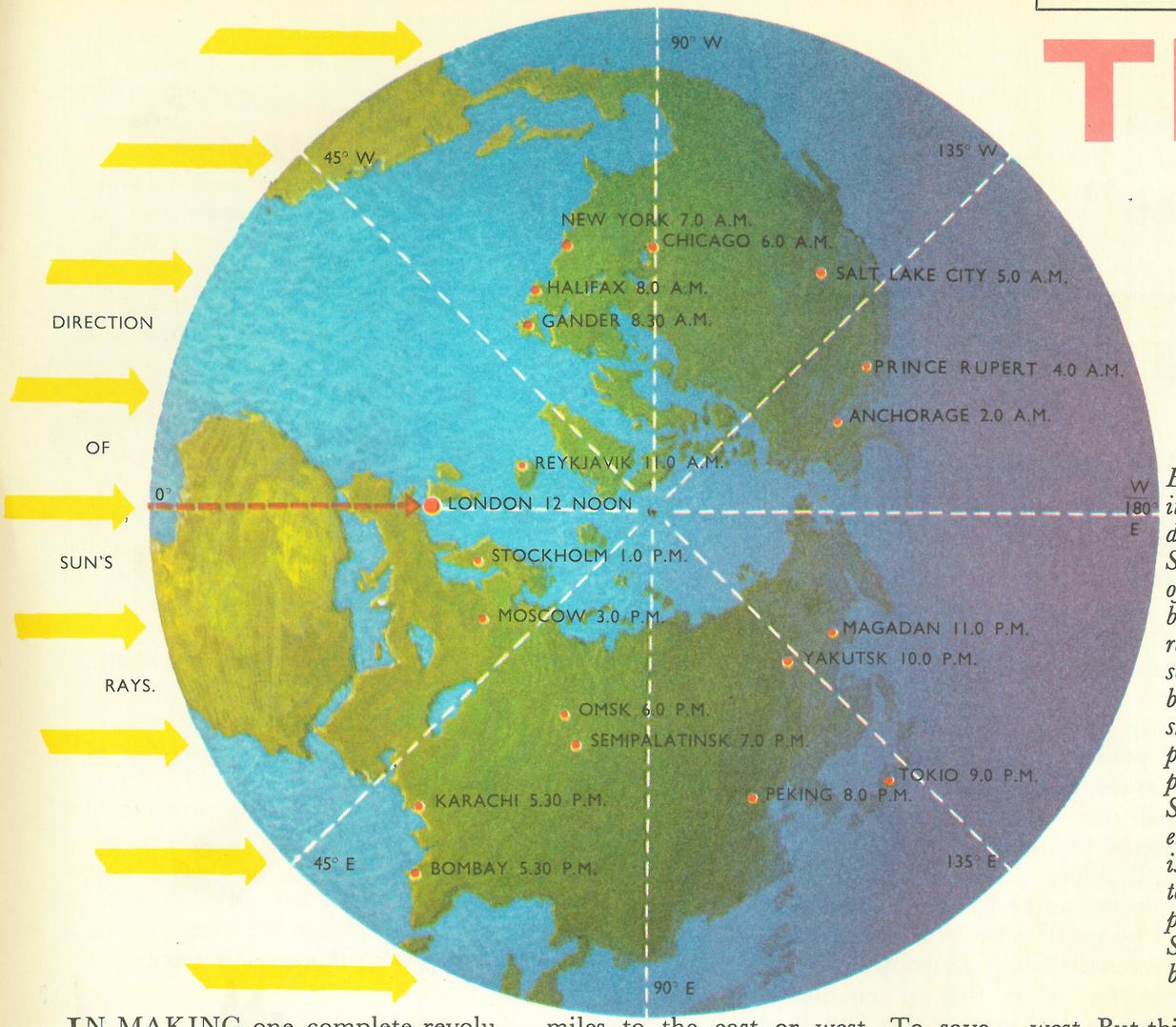
In the lamp is one of the few parts of the circuit that offers much resistance to the movement of electrons. This is the filament, a long coil of very fine tungsten wire. The electrons in tungsten are more tightly bound to atoms than they are in copper and consequently there is no easy drift of electrons through the filament. In fact the filament is made white hot by the electrical energy expended in forcing electrons through it. Unlike a fuse the tungsten wire has a very high melting point and does not break even at white heat.

Current emerging from the filament returns to the fuse box and completes its journey back to the generator through cables laid alongside the ones that carried it to the lamp.

The torch illustrated here is a familiar example of a circuit that has no wires. The current (by which we mean the conventional current from positive to negative) flows from the positive terminal of the battery. This is a central rod of carbon—one of the few non-metals that conducts electricity—fitted with a brass cap over its exposed end. Because of the chemical action going on in its battery the atoms in the carbon rod are unbalanced and have a shortage of electrons (*i.e.*, positive charge). At the same time the atoms in the zinc casing of the battery have a surplus of electrons (*i.e.*, negative charge). One end of the filament in the torch-bulb is connected to a spot of solder on the bottom of the bulb and this makes contact with the brass cap on the carbon rod. The other end of the filament is connected to the metal part of the base which screws into the reflector. Since the reflector is made of bare metal the current passes easily through it to a strip of brass leading to a switch on the side of the torch. As long as the switch is closed the current flows through it into the metal barrel of the torch itself. At the bottom of the torch barrel is a spring which serves both to hold the batteries in place and also to provide a conducting path between the torch barrel and the zinc casing of the battery. The zinc casing forms the battery's negative terminal, its side insulated by a cardboard outer casing.

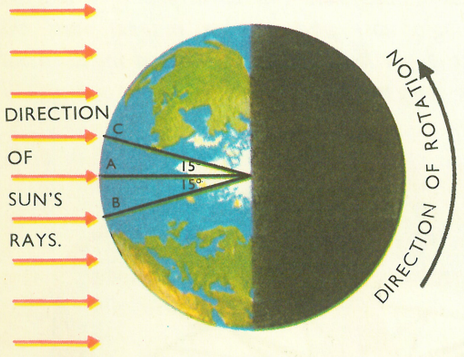
And so the current has completed its journey back to the battery. For simplicity the diagram shows only one cell whereas in practice the torch would contain a battery of two or more cells.

TIME and Time Zones

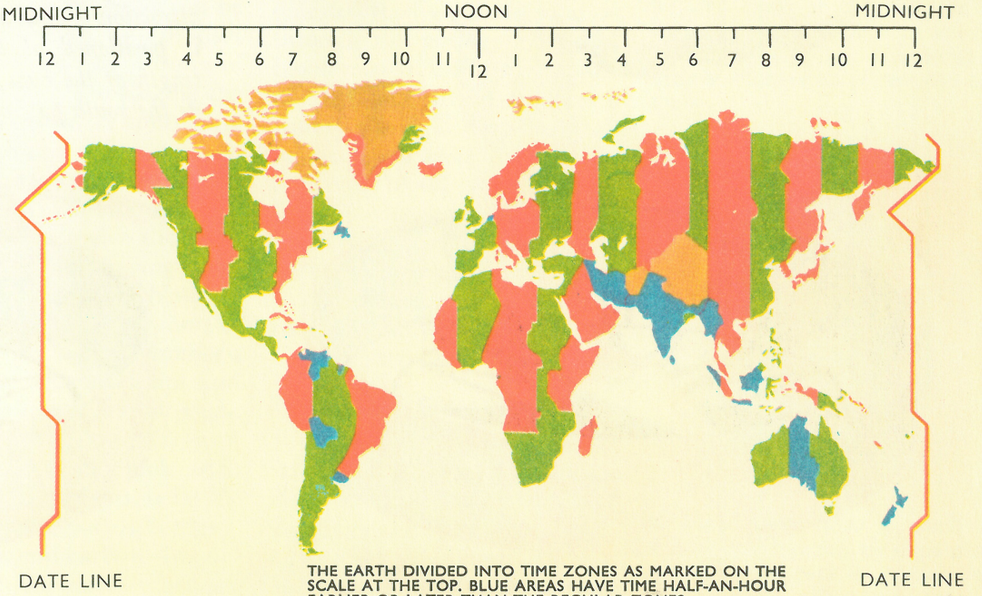


Because the Earth spins upon its axis (an imaginary line drawn between the North and South Poles) a different part of its surface is constantly being presented to the Sun's rays. It spins anti-clockwise, so when the Sun appears to be at its highest point in the sky at one place (noon), a place to the east has already passed beneath the overhead Sun—it has already experienced noon and the time there is after midday. But a place to the west will not have yet passed beneath the overhead Sun and the time there will be before midday.

IN MAKING one complete revolution the Earth turns through 360° and as it takes about 24 hours to do so there is a difference of four minutes between each degree. Thus clocks in one town should show a different time from clocks in another town a few miles to the east or west. To save confusion the world is divided into standard time zones, each varying by 15°, *i.e.*, one hour. The basis of the reckoning is noon at Greenwich (0°). Countries to the east of Greenwich have time in advance to those to the west. But this reckoning makes places either side of the 180° East or West line roughly 24 hours apart, so the International Date Line was drawn at this point. Passing westwards across it the date advances one day, passing eastwards the date goes back one day.



Above. It is noon at point A. Point B, 15° to the east, has already passed beneath the overhead Sun; it is 1 p.m. there. Point C, 15° to the west, has not yet passed beneath the overhead Sun; it is 11 a.m. there.
Right. The time zones are modified in places to avoid splitting countries, as is the International Date Line.

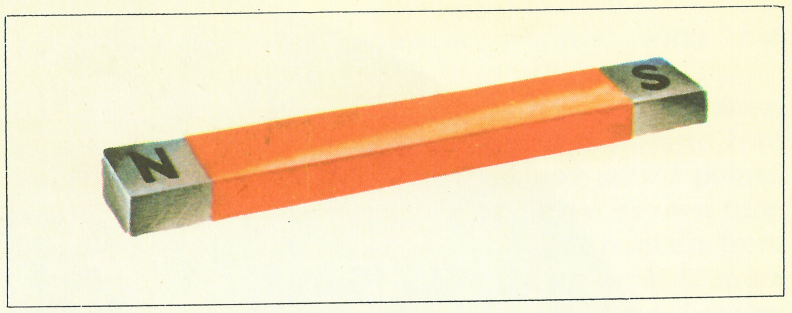


THE EARTH DIVIDED INTO TIME ZONES AS MARKED ON THE SCALE AT THE TOP. BLUE AREAS HAVE TIME HALF-AN-HOUR EARLIER OR LATER THAN THE REGULAR ZONES.

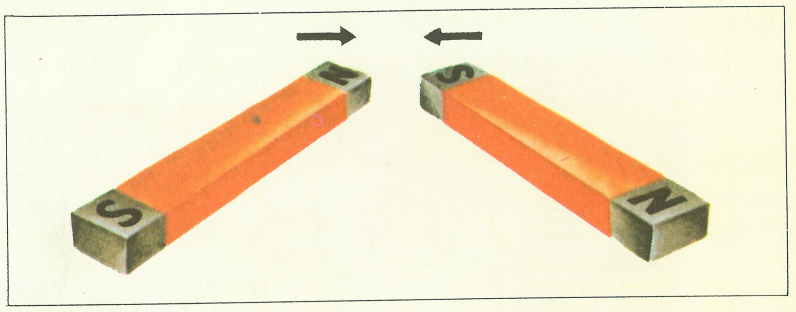
The "Loves" and "Hates" of MAGNETS

A MAGNET is a piece of iron, steel or lodestone ore which attracts to itself other pieces of iron. Every magnet has two poles (in the case of the bar magnet they are at either end of it), from which magnetic forces seem to operate. The north poles are attracted to the south poles of other magnets, but 'hate' the other norths. Similarly the souths 'like' norths, but are repelled by the other souths. Briefly put: *unlike poles attract each other; like poles repel each other.*

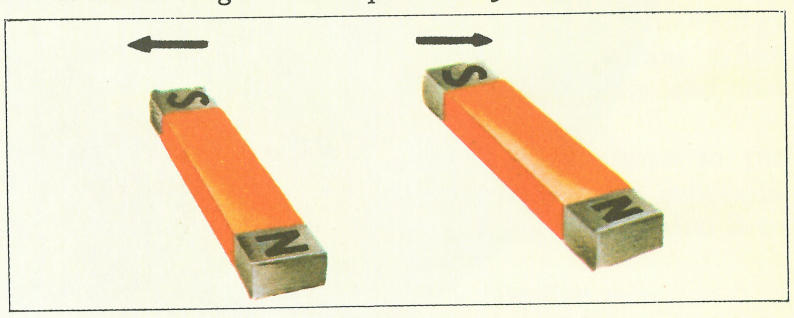
Perhaps the best known practical instance of this attraction between unlike poles occurs in our magnetic compasses. The Earth, we know, is a vast magnet and the compass needle a very small one. One pole (end) of the compass needle always points to the Earth's Magnetic North Pole; the other will never do so. The use of magnetism would seem from this to be limited to people like explorers and sailors who need to find the direction of North by a compass. But magnetism is a curious force, its most important action for us is that it enables electricity to be made by mechanical means. The first of several articles describing this appears in the next issue.



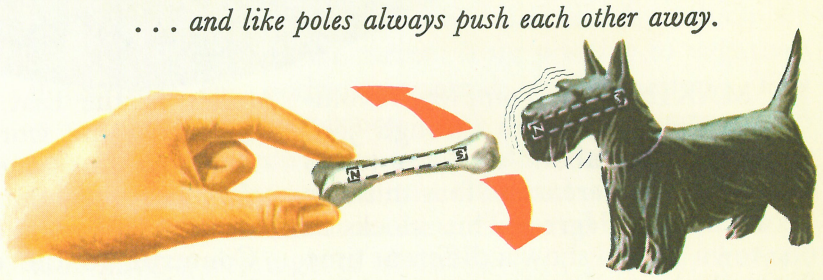
Every magnet has two poles, north and south.



With two magnets unlike poles always attract each other.

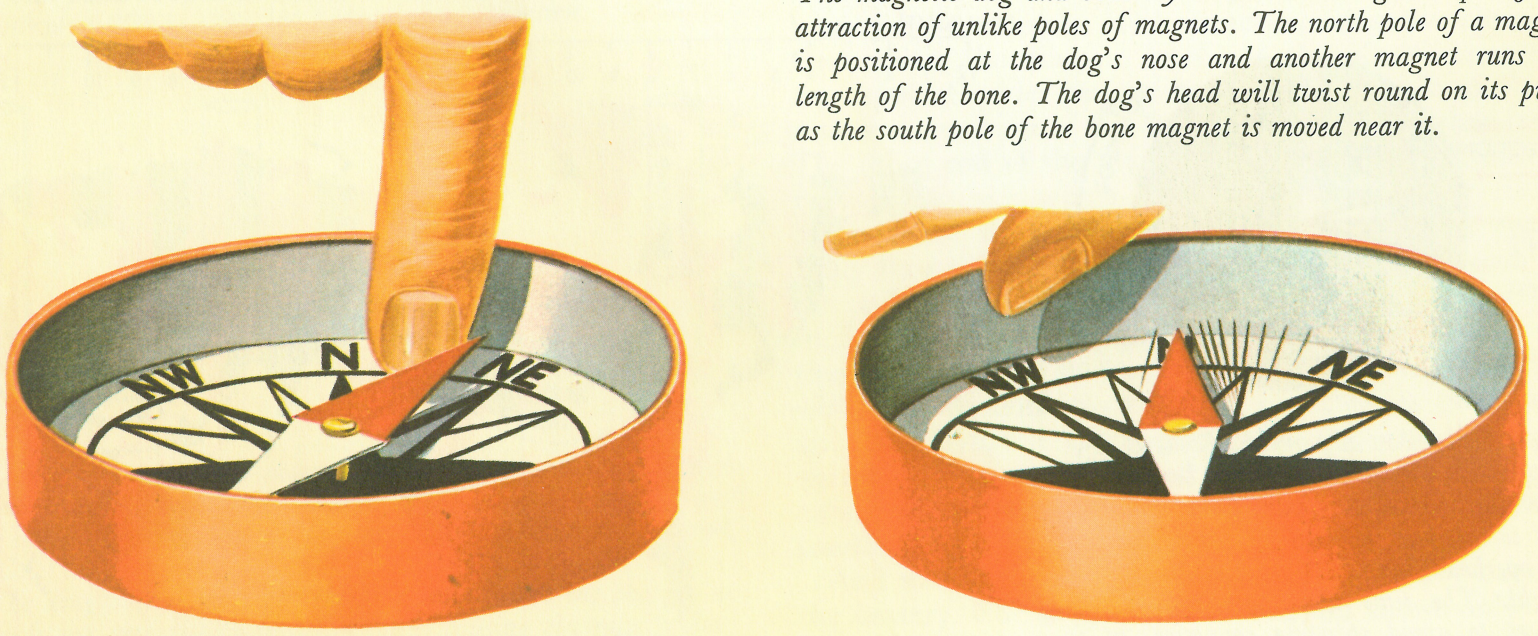


. . . and like poles always push each other away.



The magnetic dog and bone toy is an interesting example of the attraction of unlike poles of magnets. The north pole of a magnet is positioned at the dog's nose and another magnet runs the length of the bone. The dog's head will twist round on its pivot as the south pole of the bone magnet is moved near it.

THE BEHAVIOUR OF A COMPASS NEEDLE



The power of magnetism. The magnetised needle of a compass will always return to point North even after being pushed out of position.

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Contents of Future Issues

Some of the series which will commence during the next few weeks are Physiology, Optics, Sound, Nuclear Physics, Dynamics, Mineralogy, Organic Chemistry, Applied Science, Scientific Equipment, Medicine, Ecology.

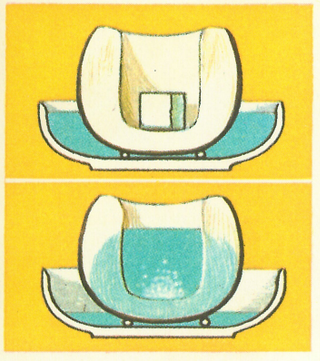
In this position in the magazine an indication will be given of when the next article in each main series is to appear and, for readers who want to keep all their issues and refer back, an indication of where the previous article in the series appeared.

The NEXT article in each of the series which commence in this issue will be as follows: Heat Physics—Issue 4; Famous Scientists—Issue 2; Atomic Chemistry—Issue 2; Technology—Issue 5; Biology—Issue 3; Electricity—Issue 2; General Science—Issue 2; Magnetism—Issue 3.

Contents of Next Week's Issue

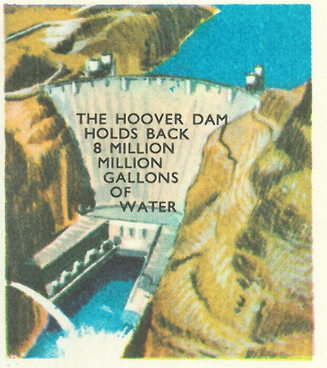
The Oxygen in the Air	*General Science*
The Magic of Mirrors	*Optics*
The Making of Electricity	*Electricity*
Vibration and Sound	*Sound*
Queen Elizabeth's Doctor Discovered the Earth is a Magnet	*Famous Scientists*
Using a Chemical Balance	*Scientific Equipment*
An Introduction to the Processes of Living	*Physiology*
The Weight of One Atom	*Atomic Chemistry*
The True Length of a Day	*Astronomy*

WATER AND LIFE ON EARTH *continued*



Experiment to show *osmosis*. Hollow out part of a potato, place a lump of sugar in the hollow and place the potato in a beaker containing some water. Water will rise *up* through the potato to fill the hollow.

Water is evaporated off the surface of the sea by the sun. Eventually it may fall over the land as rain or snow and find its way back through streams and rivers to the sea. This cycle is going on the whole time.



Some 250 million gallons of rainwater fall upon the Earth every *minute*. This sounds a lot, but it takes over two million *years* for water equivalent to the total amount in the oceans to be evaporated from the surface of the sea.

through its roots. The roots contain more dissolved substances (e.g. sugar) in solution than there are in the soil. Because of this difference in concentration inside and outside the plant, water will pass into the roots. This process is called *osmosis*.

The leaves of a plant are rich in sugar too. As water is evaporated from the outer parts of a leaf by the heat of the sun, the sap in the cells there (plants are made up of hundreds of tiny sacs called cells) becomes more concentrated. So they draw water by osmosis from the inner, neighbouring cells to replace the water evaporated. This process spreads from cell to cell back to the stem itself, so that water is drawn from the stem into the leaf.

But since water tends to stick together in a narrow tube, the whole column of water in the stem is pulled upwards, just as when you drink through a drinking straw. Water is pulled up over 200 feet above the ground in this way by the sequoia tree. It is replenished by more water entering the roots.

Another name for osmosis is the sugar-lift. The fact that sugar-lift actually works can be proved by hollowing out part of a potato, placing a lump of sugar in it and then placing the potato into a beaker containing a little water. After a time water is drawn up through the potato to fill the hollow.

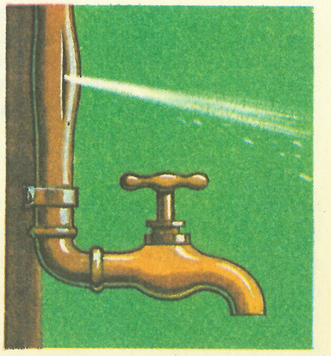
Water helps to give the parts of a plant shape, blowing them out like air in a football bladder.

When plants become short of water, as on a hot summer's day, they become limp and wilt. But water is also of prime importance to a plant in its food-making process, in which, with the energy of sunlight, it builds up complicated foods, like sugar, from water and carbon dioxide.

All the chemical reactions which take place inside plants and animals happen in a watery solution (the chemicals themselves are dissolved in water). For example, the digestion of food in the gut of an animal takes place in a watery solution which is largely water, and the digested food passes in solution through the gut wall into the blood vessels. Solid food could not do this. Blood itself is a watery fluid. If the chemicals in the blood were not in solution the blood vessels would become clogged with solids—the flow of blood would be impossible. Similarly in a plant food substances and minerals could not move about the plant if they were not in solution.

The Oceans Grow Salty

Water is able to dissolve most things. This is because it reduces the electrical forces which hold together the particles which form solid substances. Streams and rivers carry mud and pebbles to the sea but they also carry dissolved substances, mineral salts which the water has dissolved from the rocks over which it has passed. When water is evaporated from the surface of the sea the mineral salts are left behind. The water vapour may eventually fall on the land again as rain, find its way into the nearest river, and dissolve more mineral salts on its way back to the sea. This



Water expands upon freezing. An iron pipe containing water can be split apart at the moment of freezing, for the force of expansion is tremendous. The burst is usually discovered when the ice thaws.

If water seeps into a crack in a rock and freezes, its expansion can split the rock in two, a job that would otherwise require immensely strong power tools.

('Water and Life on Earth' continued on back cover)

Understanding
SCIENCE

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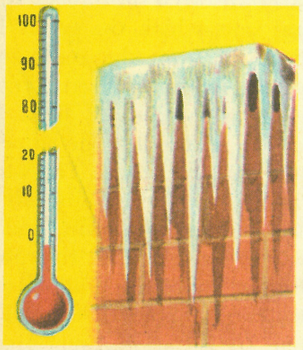
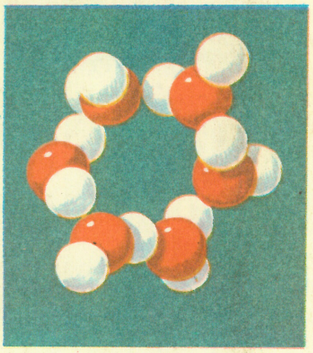
WATER AND LIFE ON EARTH *continued*

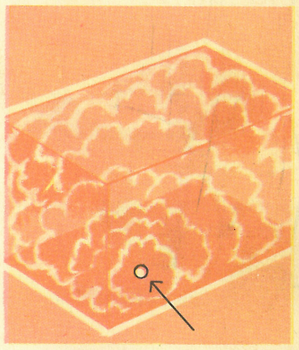


The centigrade scale of temperature is based upon the behaviour of water. 0° on this scale is the temperature at which water freezes. 100° is the temperature at which water boils.



When water freezes, its molecules, which are normally arranged haphazardly, take on a definite pattern, called a crystal lattice. This is why ice takes up more room than water.

When water turns to steam its volume increases by 1,700 times under normal conditions. This is why steam lifts the lid off a kettle. This fact is put to use in a steam engine.



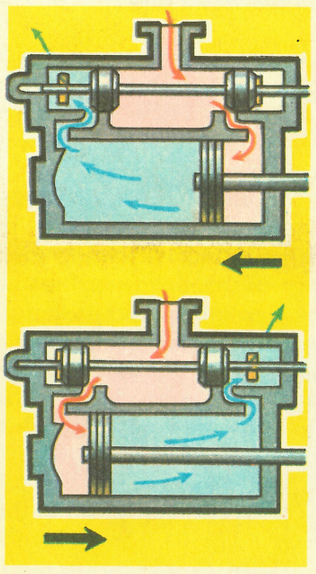
The steam produced from this one drop of water would fill this large container, for the molecules of steam (a gas) are much more widely spaced than the molecules of water (a liquid).

process has been going on for millions of years—in fact, ever since the first drop of rain fell on the young Earth. Gradually the amount of mineral salts in the sea has increased until there is now, on the average, $3\frac{1}{2}$ pounds of salt in every 100 pounds of sea-water.

Freezing and Boiling

At a certain temperature water freezes and turns into a solid—ice. On the centigrade scale of temperature, which is based upon the behaviour of water, this is defined as 0°. As water freezes it expands. Water molecules (the smallest possible pieces of water) are normally jumbled together higgledy-piggledy, but upon freezing they arrange themselves in a definite pattern (called a crystal lattice). In doing so they take up more room, or, in other words, the water expands. If water seeps into a crack in a rock and freezes, its expansion can crack the rock wide open. In a similar way water freezing in a pipe can split it apart, for the force of expansion is tremendous.

At another certain temperature water turns into a gas—steam. On the centigrade scale of temperature the point at which this happens is defined as 100°. What happens is that the water molecules, which, although held together by forces of attraction, are constantly moving and bumping into each other, move more and more vigorously when heated. They bump harder and bounce off farther apart until finally they break free of the attraction of their neighbours. Once they have separated they fly about freely as gas molecules. When water changes to steam its volume increases about 1,700 times because its molecules become so widely spaced. This is why the lid of a kettle rises when the water inside is rapidly being turned into steam. The same principle is used in the steam engine. Steam is produced by heating water in a boiler. The steam cannot expand sufficiently in the confined space of the boiler and will move the piston in a cylinder in order to do so.



Using steam to drive the piston of an engine. Steam from the boiler is passed through a valve into the cylinder (*top*) where it is then able to expand by pushing the piston head along the cylinder. At the same time the moving piston pushes 'spent' steam out through another valve. When the piston has reached the other end, more steam is allowed into the cylinder in front of the piston head which is then driven back again.

It is possible to turn water into a gas, steam, by heating it, but it is also possible to turn the steam back into water—by cooling it. This process of turning a liquid into a gas by heating it and then back into a liquid by cooling it is known as *distillation*. It is a process which can be put to a number of uses, one of them being to obtain pure water. Water normally contains a considerable amount of impurities. If the water is turned into steam the impurities are left behind. The steam can then be led to another vessel where it cools and condenses back to water—but without the impurities. In all delicate chemistry experiments which call for the use of water, distilled, or pure, water must be used.